

**Original article****□ Mirror neurons and the 8 parallel consciousnesses**

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**SUMMARY:** *To understand the mechanisms that shape consciousness and the evolutionary advantages it confers, identification of the neural correlates of consciousness (NCC) is considered to be of fundamental importance. Hence, by reviewing neglect pathology, I set out to identify the brain areas whose damage causes the loss of consciousness without preventing unconscious perception. Once these areas had been identified, by analysis of the resulting neglect I sought to define a distinction between areas responsible for access to consciousness and those responsible for consciousness itself. This approach led to the identification of the anterior cingulate and the precuneus-posterior cingulate as components of access to consciousness, while the medial-superior temporal lobe, the superior parietal lobe, the anterior insula, the posterior insula, the lateral motor cortices BA 8 and BA 6, the inferior frontal lobe and the inferior parietal lobe appeared to correspond to 8 distinct and autonomous parallel real consciousnesses. Acting simultaneously, these areas give us 8 contemporaneous conscious sensations, respectively, namely 1) image perception, 2) spatial image positioning, 3) emotions related to these images, 4) presence on the scene, 5) possibility to move oneself in the scene, 6) possibility to move single objects, 7) possibility to move more than one object, and 8) feeling of being subject spectator in the theatre of consciousness. The evolutionary advantages provided by the conscious process are the ability to learn rapidly (without long training/trial and error) and a problem-solving approach mediated by mental images. All the 8 consciousnesses detailed above are thought only to be present in humans, developing as we climbed the evolutionary ladder, bringing new memory and reasoning skills, from the primitive consciousnesses that first appeared in reptiles. The neural correlates of these consciousnesses bear a striking anatomical and physiological resemblance to mirror neurons. Like the mirror neurons, the NCCs are active when we perceive both external and mental images. The seductive hypothesis that mirror neurons are in fact the NCCs is therefore also discussed.*

**KEY WORDS:** *Attention, Brain evolution, Function of consciousness, Mirror neurons, Perception.*

**□ INTRODUCTION**

Consciousness is the continuous sequence, during our waking hours, of external and internal images, of abstractions, actions, emotions, perceptions of our body and, in general, of anything that make us feel watchful. It also involves the subjective feeling of being present on the scene where events are occurring, and of being responsible for them in some way.

Authors such as Damasio<sup>(14,15)</sup> and Edelman<sup>(21)</sup> have argued, albeit in slightly different ways, that there are different levels of consciousness. However, according to these Authors, these levels of consciousness would be overlapping, interdependent and non-parallel. According to them there would be a primitive level (the only one that can stand alone), along with a further two advanced levels, which are present only in humans. An injury on the first level would prevent the existence of the two successive levels, and, simi-

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**LIST OF ACRONYMS AND ABBREVIATIONS:** **BA** = Brodman Area; **fMRI** = functional Magnetic Resonance Imaging; **NC** = Neural Correlate; **NCC** = Neural Correlates of Consciousness.

larly, injury to the second would block the third level of consciousness. The theoretical research I have conducted suggests that, instead, there are 8 separate types of consciousness, which, although interlinked, are capable of acting independently.

Nevertheless, another of Damasio's theories<sup>(14)</sup>, namely that levels of consciousness are linked to particular brain areas, which act as points of convergence, simultaneously holding the image of the object and the emotions (or memory of the emotions) generated by the object, does bear striking parallels with conclusions drawn from my research, and, in fact, mirror neuron theory. These issues will be discussed in depth below, but the "hard problem" concerning consciousness is the following: how is the brain able to generate the subjective experience of the self admiring a nice landscape, listening to music, wondering or simply living their everyday life? How can the brain, built of matter, give rise to these immaterial experiences? Consider the first epic chess match in which the machine, the IBM Supercomputer Deep Blue, defeated man, the world champion Gary Kasparov. Although both players were made of matter, there were clear qualitative differences between them, the so-called qualia, which form the peculiarities of consciousness. Nobody thinks that this computer "sees" or "lives" the chessboard as the man does when playing. Instead, the superior performance of supercomputers such as these are due to their tremendous memory and calculation speed, which are used by fundamentally static programs defined by software programmers.

Trying to explain how brain activity can participate in the self, some Authors, like Descartes<sup>(14)</sup> and Eccles<sup>(48)</sup>, hypothesized the existence of an anatomical part of the brain that linked it to the immaterial soul, an explanation that is clearly unlikely to satisfy those of a scientific bent. Other Authors<sup>(18)</sup> assert that it is premature to try to solve the hard problem, and we would be better to focus on the location of the neural correlates of the access to consciousness. However, in this article I will have a speculative stab at both, by postulating the location of the neural correlates of the access to consciousness and consciousness itself, and providing a tentative explanation of the conscious process.

By the neural correlates of the access to consciousness,

we mean the brain areas responsible for the attention-access and memory-access specific to consciousness, without which the appearance of consciousness would not be possible. These concepts are very different from the unconscious attention and memory implicated in the perception of animals that are not conscious, i.e., fish, in whom unconscious attention is needed to focus on some goal (e.g., food) selected by their emotions. In such beings, unconscious memory is needed to store images relating to previous experiences so that they can be recognized, and duly acted upon, at a later date. As we will see, unconscious emotion, attention and memory are also used in conscious animals to identify (unconsciously) the object of perception that the attention access and memory access will make conscious. This attention access is thought to serve to activate evolutionary new brain areas, present only in conscious animals, namely the neural correlates of consciousness. In theory, these connect and simultaneously activate the cortical areas dedicated to external perception and the corresponding brain areas responsible for memory access of similar or equivalent perceptions. In this way, the NCCs are thought to give rise to conscious perception.

In order to shed light on these issues (NC of access to consciousness and NCC) we reviewed a large body of work on neglect pathology. Theoretically speaking, identifying the effect of neglect in certain areas should enable the development of further hypotheses on the functioning of consciousness and the evolutionary advantage it provides, thereby providing a tentative solution to the hard problem of consciousness.

## □ METHOD

The working method adopted here used the two following criteria to identify the brain correlates of access to consciousness and consciousness. The first was aimed at identifying the parts of the brain that are solely responsible for consciousness. Indeed, there are areas whose injury causes damage to consciousness but whose function is not dedicated exclusively to this task<sup>(61)</sup>. For example, a severe injury to the brainstem, located at the base of the brain, can cause coma. In this situation, evidently, conscious perceptions

are absent, but so are unconscious perceptions, therefore the brainstem does not fit our profile. Instead, we need to look for brain areas whose injuries prevent the existence of consciousness, but do not compromise unconscious perception. After identifying such areas, the next step is to distinguish between those areas that control access to consciousness and those that can be considered NCCs.

In order to achieve the primary endpoint (identifying brain areas whose sole function is consciousness), a large body of work concerning neglect pathologies was reviewed. Neglect is a disorder characterized by loss of consciousness of sensorial information on the left. It is usually caused by unilateral lesion in the right part of the brain, in even just one of the different areas with specular counterparts in the left hemisphere. Only the lesion on the right is capable of causing the disease, because it seems that the right brain is able to perceive both sides of external space, while the left hemisphere seems to perceive just that on the right. Hence, if the left side is injured, there would not be strong evidence of loss of consciousness, as the right brain can perceive all space. Instead, a lesion in the right brain does not allow perception on the left because the intact left brain is only able to perceive the information present on the right<sup>(30)</sup>. Thus the patient with neglect is not able to report which images are present on the left side of their environment, and shaves only on the right, etc.<sup>(16)</sup> However, it has been shown that such a person is able to unconsciously perceive the images placed on the left<sup>(43)</sup>. This makes neglect an ideal situation for identifying the correlates of cerebral consciousness. Indeed, the first of the above 2 criteria is fulfilled, i.e., a lack of consciousness in the presence of unconscious perception.

Due to these factors, neglect has long been a focus in the study of consciousness, especially concerning the role of attention (access) in conscious perception. However there is a dispute regarding the cause of the neglect: for some it is due to an attention deficit, for others, to a lesion of the conscious representation<sup>(62,63)</sup>. To satisfy both parties, neglect is now being described not as a unitary disorder, but as a complex set of attention and consciousness deficits<sup>(2,62,63)</sup>. So the areas that are subject to neglect should correspond to the sum of the areas responsible for access to consciousness (attention areas, and in my opinion, even memory) and those responsible for consciousness itself.

To fulfil the second criterion, that is to distinguish the correlates from the Access to the NCC, once all brain areas whose damage causes neglect have been

identified, we need to identify which areas can be linked to access to consciousness, and to propose that the remaining areas correspond to the NCCs. With this objective in mind, in addition we set out to examine the consequences of bilateral lesions resulting in the neglect. Thus it became apparent that there are 2 distinct areas where bilateral lesion results in total loss of consciousness, making them seem ideal candidates for the access-to-consciousness function. Furthermore, bilateral lesion of each of 8 other separate areas causes only loss of the corresponding type of consciousness, preserving the functionality of the other 7, indicating them as the NCs of 8 different and parallel consciousnesses.

#### □ THE NEURAL CORRELATES OF ACCESS AND CONSCIOUSNESSES

Examination of the literature reveals a total of 10 areas whose damage apparently causes right-sided spatial neglect<sup>(10,28,42,62,63,65)</sup>, namely the anterior cingulate (Brodmann area BA 24-32), the precuneus-posterior cingulate (BA 23, 7, 31), the posterior insula, the anterior insula, the medial-superior temporal lobe (BA 22, 37), the superior parietal lobe (BA 7), the lateral motor cortex BA 8, the lateral motor cortex BA 6, the inferior frontal lobe (BA 44-45-46) and the inferior parietal lobe (BA 39,40). Due to the key role of the anterior cingulate in conscious attention<sup>(49)</sup>, it can be allocated to the access-to-consciousness group without further ado. Similarly, the precuneus-posterior cingulate cortex, as the seat of higher-order memory and a source of mental images, should belong to the same group. Indeed, there exists a considerable body of literature<sup>(5,8,9,67)</sup> in support of the fundamental role of this large parietal area in the different types of memory (semantic, episodic and autobiographical) and in the production of mental images.

If the anterior cingulate and precuneus are the access to consciousness, let us suppose that the remaining 8 areas correspond to the NCC. By careful examination of neglect, it is possible to obtain confirmation of this preliminary supposition, and to understand how these 8 NCCs control 8 different and wholly independent consciousnesses. First, damage in the right hemisphere to even a single one of each the 10 areas we are examining is sufficient to cause the complete loss of left-side spatial awareness. This would suggest that consciousness is formed of 10 closely related and interdependent parts. If this were true, we would

expect that a bilateral lesion (that is both right and left) to one of these cortical areas would be sufficient to cause the loss of both left and right spatial awareness, i.e., a total loss. In actual fact, this effect is only produced in 2 of the 10 areas, namely the anterior cingulate and the precuneus, i.e., our NCs of access to consciousness. Indeed, in monkeys bilateral anterior cingulate cortex lesions cause an inability to perform abstract reasoning: the animal can learn only with the stimulus-reward-response routine<sup>(55,59)</sup>, as do fish and amphibians, which are presumably not conscious. Likewise, Damasio<sup>(15)</sup> describes 2 patients with “zombie-like” behaviour, one of whom had a lesion of the anterior cingulate and the other a lesion of the posterior cingulate-precuneus. These subjects could only perform automatic actions without being aware of it.

Bilateral lesion of each of the other 8 areas may cause some deficits, but not enough to prevent consciousness as a whole. For example, bilateral lesion of the medial-superior temporal cortex causes semantic agnosia<sup>(54)</sup>, that is the inability to recognize objects, and therefore a loss of conscious perceptual ability, while the other functions of consciousness remain intact, i.e., the patient is still conscious of their movements, body, emotions and so on<sup>(27)</sup>. In a similar way, bilateral lesion of the superior parietal lobe only causes simultagnosia, the inability to perceive more than one object at a time. The patient cannot see the environment as a whole and can only examine it at a particular point in time<sup>(62)</sup>, but the remaining functions of consciousness continue to be present. Bilateral damage to the frontal premotor areas also fails to produce severe deficits, but it does cause various types of apraxia. These disorders of voluntary movement become evident only when the patient tries to carry out motor tasks that cannot be performed automatically, like those which involve complex motor sequences, producing symbolic gestures or mentally representing a particular movement.

Although these data appear to confirm the role of the anterior cingulate and of the precuneus as the constituents of the access to consciousness, as bilateral lesion in one or in the other prevents the emergence of consciousness itself, the other data only leads us to assume that there are 8 different parallel consciousnesses, interacting with each other but independent, and therefore capable of autonomous existence, as bilateral lesion damage to each one of them does not affect consciousness as a whole to any great extent. To explain how, in neglect pathology,

damage to a single of the 8 potential NCC areas in the right hemisphere is sufficient to cause the complete loss of consciousness on the left, we must bear in mind that, although not interdependent, these areas do interact. Hence, the lesion of just a single NCC in the right brain disconnects it from the other 7 and effectively weakens the entire right side in favour of the left. When the lesion is bilateral, the deficiency affects right and left sides of the brain to the same extent. This establishes a balanced weakening of only the consciousness driven by the two damaged symmetrical areas, without affecting the other consciousnesses.

To obtain a total loss of consciousness, therefore, it would be necessary to cause bilateral damage to the neural correlates of attention or memory or, alternatively, the neural correlates of all 8 consciousnesses. This presumably occurs in dementia, particularly in Alzheimer’s disease (which, in my opinion, produces the most fitting clinical example of “zombies”), as the damaged brain areas<sup>(23,32)</sup> in this disease correspond almost perfectly with the above-described NCCs. The first symptom of this disease is memory impairment due to lesions of the hippocampus, which is thought to play a role in storing environmental images and accessing them during later recall. In subsequent phases of Alzheimer’s, the brain progressively deteriorates, generating gradual amnesia for semantics, motor apraxia, temporo-spatial disorientation, personality changes, severe speech impairment and loss of the patient’s awareness of their deficits, until all autonomy is lost. All of these symptoms are caused by lesions in areas coinciding with the NCCs, and, naturally, if the lesions involve the immediate anterior cingulate or precuneus, i.e., the access to consciousness, consciousness deteriorates more rapidly.

By studying the different ways in which neglect can appear, through functional magnetic resonance imaging of the injured areas, we can obtain further confirmation that the 8 NCCs may control 8 different types of consciousnesses. Indeed, several studies into neglect<sup>(28,65)</sup> have shown intriguing findings to this effect when these areas are damaged. For example, lesions in the posterior right insula cause hemisomatagnosia<sup>(37)</sup>, a loss of corporeal consciousness in half of the body. In severe cases, patients may come to believe that their right leg belongs to a stranger, and attempt to throw it out of bed (somatoparaphrenia)<sup>(64)</sup>. A lesion to the anterior right insula, on the other hand, causes anosognosia<sup>(37,66)</sup>, a lack of

awareness of disability, in this case left leg paralysis, thought to be due to an emotional deficit. This deficit is so strong that the patient may claim to be able to undertake various sporting achievements<sup>(14)</sup>. The functions of these 2 brain regions are confirmed by fMRI studies showing activation of the posterior insula during body awareness<sup>(60)</sup>, and the anterior insula during emotion<sup>(56)</sup>. Likewise, damage to the right superior temporal and/or medial temporal lobe causes a particular type of neglect, known as allocentric neglect<sup>(11)</sup>, which is mainly focused on the perception of objects, i.e., “what” the patient sees. It is characterized by the fact that the patient can explore space to their right and left, but does not have the perceptual or semantic awareness of the left half of objects, irrespective of their spatial position<sup>(31)</sup>. As previously mentioned, bilateral lesion causes semantic agnosia. The fMRI data showing that these areas are active in both perception and in imagining objects<sup>(44)</sup> will be discussed below.

Lesions of the right superior parietal lobe cause spatial neglect, depriving the patient of positional awareness, making them lose the “where” of objects in the left side of space. Furthermore, damage to the right BA 8 causes motor extrapersonal neglect, while lesions in the right BA 6 in the dorsolateral frontal lobe causes motor peripersonal neglect<sup>(12)</sup>. These patients are not aware of their movements in left-side space, either near or over their own body. In contrast, a BA 44-45-46 lesion in the right inferior frontal lobe causes a self-centered motor neglect, characterized by the inability to perform a particular action sequence. fMRI confirms the involvement of these 3 motor areas in the 3 respective movements<sup>(28,65)</sup>.

Damage to the right inferior parietal lobe causes egocentric spatial neglect with a loss of awareness of the position of the body in left-hand space. fMRI has highlighted the role of this area in situations where there is a first-person perspective, such as the identification of the patient’s position in space, the imagination of an act or the representation of their own body<sup>(41)</sup>. Stimulation of this area causes the patient the sensation that they are levitating and looking down on their own body from above<sup>(4)</sup>.

Thus, the posterior insula is apparently responsible for body consciousness (including hunger, thirst, etc.), the anterior insula for emotional consciousness (pleasure, pain, fear, etc.), the superior temporal lobe for perceptual or semantic consciousness (the “what”), the superior parietal lobe for consciousness of the spatial position of objects (the “where”), the

motor cortex BA 8 for personal motor consciousness (movement in space), the motor cortex BA 6 for peripersonal motor consciousness (movement of the hands of the monkey, near or on its own body), the inferior frontal lobe for subjective motor consciousness of being the doer (consciousness of a sequence of actions, i.e., self-recognition in a mirror, and the ability of chimps to stack boxes to retrieve a banana), and the inferior parietal lobe for subjective spatial consciousness of being the spectator, that is the feeling of being present in the Theatre of Consciousness.

## □ HYPOTHESIS ABOUT THE VARIOUS STAGES OF CONSCIOUS PERCEPTION

We now examine the different steps that may occur during conscious perception. For simplicity’s sake we will refer only to conscious visual perception because this has been the most studied to date. Hypothetically speaking, the entire sequence would unfold as follows:

- Step 1.* Emotion guides selection of the most important image from those unconsciously reaching the occipital lobe from the outside world.
- Step 2.* The thalamus focuses unconscious attention on that particular image.
- Step 3.* The image “moves” from the occipital lobe to the inferior temporal lobe.
- Step 4.* From the inferior temporal lobe it then “moves” to the superior temporal lobe.
- Step 5.* The anterior cingulate cortex, seat of attention access, keeps the image active in the medial-superior temporal lobe (NCC) for 300 ms, long enough for it to become consciously perceived.
- Step 6.* During this time interval, the visual NCC keeps the brain areas in control of the external image interconnected with those in control of the specular image of Memory-Access. The simultaneous activation of these two brain areas gives the feeling of conscious perception.

Looking at *Step 1* more in depth, many Authors, including Panksepp<sup>(47)</sup>, LeDoux<sup>(38)</sup>, Damasio<sup>(14,15)</sup>, Edelman<sup>(21)</sup>, and, more recently, Denton<sup>(20)</sup>, have shown, albeit with different emphasis, that there is a close bond between the emotional values system, innate and acquired, and consciousness. Following this line of reasoning, among all the images perceived

unconsciously at any given moment, emotion selects that most important to the viewer. For example when you enter a room, you get an immediate unconscious overview of the objects in the room. If you are hungry, it is likely that your emotion centres will select a sandwich to bring to the fore, whereas if you are thirsty, a glass of water, or if you are looking for something, the object you are searching for, etc. According to this theory, even the solutions to mathematical-abstract reasoning problems are likely to be selected through the emotion that signals their correctness. In terms of visual perceptual consciousness, it is known that environmental images do in fact arrive at the occipital lobe: first to the primary cortex V1 and then to secondary V2-V3. Given the connections between V2-V3 and emotional centres<sup>(34,58)</sup>, it can be hypothesized that perceptual information is sent from these visual areas to emotional centres like the amygdala, septum, and n. accumbens. Here it would be subject to a selective evaluation on the basis of innate needs (hunger, thirst, seizure of territory, etc.) or needs acquired over time.

The product of this selection would then arrive at the thalamus (*Step 2*), responsible for selecting the image. Indeed, many Authors (e.g., Crick<sup>(13)</sup>) ascribe the thalamus' great importance as the seat of attention. As this attention is also present in fish and other supposedly unconscious animals, it cannot be considered as directly related to consciousness, so herein we will refer to it as "unconscious" attention.

In *Step 3*, the thalamus would act in such a way that perception of the selected stimulus is transferred from the occipital lobe to the inferior temporal lobe neurons that are able to unconsciously recognize the identity of the selected object (e.g., a sandwich, a glass of water, lost keys, etc.). This is confirmed by the work of Logothetis<sup>(40)</sup> on vision, which demonstrates that only the image that will later become conscious reaches the inferior temporal lobe, while the images that remain unconscious do not go beyond the occipital lobe. Evolutionarily speaking, all of these mental operations that lead to selection and unconscious perception are also present in fish and amphibians, which are considered here to lack consciousness. In higher species, evolution produced new brain structures, which are precisely the neural correlates of access to consciousnesses and consciousness itself. It is hypothesized that in the brain of conscious animals, the unconscious part, similar to that possessed by fish, serves to select the perception that will become conscious.

In conscious animals the image would pass from the inferior temporal lobe responsible for unconscious visual perception to neurons in the medial-superior temporal lobe (*Step 4*), which may postulated as the NCCs responsible for perceptual or semantic consciousness. In theory, these neurons are responsible not only for visual consciousness, but also for the consciousness of all the perceptions arriving from a particular object through all five senses, which enable the identification of the semantic object itself. In fact, inferior temporal lesions cause visual agnosia, i.e., the patient is unable to recognize certain objects visually, but they can identify them by touch or smell, for example.

Similarly, lesions of tactile sensory areas can cause tactile agnosia without impairing the ability of recognition through other, undamaged, pathways. The difference between visual perception and, for example, tactile perception<sup>(68)</sup> of the same object will depend on the difference between the two respective sensory cortices. Medial-superior temporal damage, on the other hand, causes semantic amnesia, completely blocking object recognition by any of the 5 senses<sup>(54)</sup>.

Regarding *Step 5*, according to Libet<sup>(39)</sup>, the interval between unconscious perception and awareness is 300 ms. The anterior cingulate (attention access directly linked to consciousness) would have precisely the function of activating the medial-superior temporal lobe and the NCC responsible for the other consciousnesses. In this way they exert their action and the percept becomes conscious.

As mentioned in the introduction, some Authors have stated that for now we should limit ourselves to just studying access to consciousness, as neither identifying the NCCs nor solving the "hard problem" seem to be feasible at the present time. These Authors have used magnetic resonance imaging to identify the neural correlates of access to consciousness<sup>(17,19,24)</sup>, and, looking at their results, from the standpoint we take in this article, you can actually see that the areas that these Authors consider as neural correlates of Access include many of our NCCs. In fact, from these works we can extrapolate that 150 ms after the onset of a visual stimulus on the screen occipital lobe activation occurs (visual impulses), in 200 ms that of the inferior temporal lobe (unconscious visual memory), in 300 ms the anterior cingulate (attention), and in 350-400 ms the superior temporal lobe (NCC of perceptual consciousness). Simultaneously the precuneus (memory) and other areas such as the inferior parietal lobe

and inferior frontal lobe are activated, which we hypothetically label as NCCs.

During *Step 6*, the NCCs would function as a point of convergence. In the specific case of visual consciousness, the medial-superior temporal lobe would keep simultaneously active both the occipital and inferior temporal cortices responsible for visual perception and the precuneus-posterior cingulate seat of conscious memory. So, to obtain conscious external perception, in addition to the image arriving from the environment, the corresponding specular memory for that picture would need to be simultaneously activated and superimposed. Conversely when the consciousness is arrived at through visual mental images from the memory, as the precuneus-posterior cingulate, the superior-medial temporal lobe would also need to keep simultaneously active the neurons in the sensorial cortices (occipital and inferior temporal), which have been the source of the external visual perception in the corresponding previous experiences. There would therefore be continuous feedback and alternation between activation of the neurons responsible for perception and those responsible for memory. With mental images there would obviously be a predominance of precuneus memory, while during external perception the prevailing activities would be in the sensory cortices. In confirmation of this hypothesis, fMRI studies<sup>(25,44)</sup> have shown that the neurons of the inferior, medial-superior temporal lobes and the precuneus are active both when an image of an external object is visualized and during mental imagery of the same object from memory. There is also a gradient of increased activity in the inferior temporal lobe for the external image and vice versa in the precuneus during mental imagery. This situation is mirrored when one makes a mental image of a movement<sup>(29)</sup>, which always stems from the precuneus. This also provokes activation of the BA 6 of the frontal lobe (NCC of the peripersonal motor consciousness) and the primary motor area, both of which are also active when one actually makes the movement.

Extrapolating from these findings, prolonged attention from the anterior cingulate would enable not only the NCC of perceptual consciousness to function, but also the NCCs that control the other consciousnesses to process their tasks. For example, the superior parietal lobe would act as a point of convergence between the neurons that sense the spatial position of the object and recollection of the same or similar positions in stored memories. Similarly, the NCCs of the different

consciousnesses, in addition to feelings stimulated by the external image, would activate the memories related to some need (body consciousness), emotion (emotional consciousness), potential movement (motor consciousness), potential sequence of actions (Author consciousness) and the physical presence (spectator consciousness) that this particular image has aroused in the past. In this way, the 8 different consciousnesses would take shape in a simultaneous and parallel manner. All these consciousnesses would be related to that particular object or event perceived in its surroundings. The experience of this conscious perception would then form a new memory that could later give rise to a new mental image. Therefore, consciousness of an object or a landscape is continually being updated as new memories are formed.

This conjecture seems to be supported by the work of A. Just<sup>(33,45)</sup>, who has shown that when we think of an apple, for example, this gives rise to simultaneous activation of brain areas dealing with the memory of the form, colour, flavour, taste and touch of an apple, and those related to our previous experiences of apples, whether these memories be motor (e.g., handling or biting into an apple), episodic (e.g., Adam and Eve) or autobiographical (related experiences). When this occurs, the main areas activated<sup>(33)</sup> are in fact the superior temporal, inferior parietal, superior parietal, lateral frontal motor, and inferior frontal cortices, and the insula - practically all of the NCCs postulated in this article as driving the 8 consciousnesses. What is more, other active areas are the precuneus (memory) and the primary cortices like the occipital lobe, responsible for primary visual perception, and the inferior temporal lobe, which stores the unconscious memory of the object. The anterior cingulate was not mentioned in Just's experiment, but this may be due to the experimental conditions used.

## □ THE HARD PROBLEM

Interestingly, the simultaneous and coordinated activation of 8 different consciousnesses with their specific percepts and their associated memories could also provide us with a partial explanation of the "hard problem" of consciousness.

Actually the human brain thinks in 3 or 4 dimensions most of the time. With this larger number of dimensions, the subjective feeling of the self seems immaterial, which is why the solution to this problem,

falling outside our capabilities, seems so “hard” to find.

A fundamental role in this model is played by the precuneus, which seems to be the single source of memories for all the different consciousnesses. The feeling of a unique consciousness is thus given by the contemporaneity of all the different conscious perceptions linked together by the precuneus.

#### □ **HYPOTHETICAL ROLE OF THE 8 CONSCIOUSNESSES**

So, let us examine the function of these consciousnesses and the evolutionary advantage they confer. The NCCs of the various consciousnesses are the areas that are activated during learning and memory<sup>(8,9)</sup>, areas whose injury prevents the formation of mental images<sup>(26,57)</sup>. We can therefore speculate that the functions of the consciousnesses are to enable rapid storage of memory and producing imagery. The primary evolutionary advantage of such a system would be to enable conscious animals to quickly process and store information from the environment and others without the need for long training by trial and error. This ties in neatly with the link between consciousness and memory - while we are able to recall the events of our conscious life, we retain no memory of events that occur when we are in a state of unconsciousness, i.e., sleep-walking, hypnosis, anaesthesia, or even when we perform routine tasks. This is why we cannot always remember having locked the car or where we put our glasses, as these are things we do automatically, without being conscious of our actions. For the same reason we often have no memory of what we unconsciously saw while driving along a well-known road - we have effectively been on autopilot, without conscious attention.

The second evolutionary advantage for conscious animals is the ability to use mental imagery to make predictions, to create expectations and to solve problems, even in the absence of corresponding environmental stimuli - an enormous boon from an evolutionary perspective. In this regard, Derek Denton<sup>(20)</sup>, in his chapter on consciousness in animals, reports the following quotes, which we will also borrow, that advocate the idea that the function of consciousness is precisely to create mental images.

The idea of purpose is an integral part of the concept of mind, and equally the idea of intention. It can be said, I think, that an organism capable of having

intentions possesses a mind [...] to develop a plan and to make a decision, that is to adopt the plan. The idea of developing a plan requires in turn the ability to build an internal model of the world (C. Longuer-Higgins in “The Development of Mind”, 1973)<sup>(35)</sup>.

The characteristic feature that defines the intent is to be a property of mental life that refers to any entity which at that moment is not observable. Intentional thoughts are therefore different from other thoughts directed to a purpose, in which the goal is clearly in sight. [...] Trying to give a general definition of intentionality, one could say that it corresponds to the state of the individual planning an action or waiting for it to occur with respect to some situation that is not directly present (J.Z. Young: “Philosophy and the brain”, 1986<sup>(69)</sup>).

#### □ **HOW CONSCIOUSNESS MAY HAVE EVOLVED**

Let us now examine the degree to which the NCCs and their consciousnesses are present on the various rungs of the evolutionary ladder. Here we assume that fish and amphibians are not conscious. It has been shown<sup>(20)</sup> that these animals possess primordial cortices, able to handle, unconsciously, complex motor activities, sensory perception and memory. They also possess an emotional system (amygdala, nucleus accumbens, lateral hypothalamus) able to select between the various external stimuli, and the thalamus as a system of unconscious attention. Such a system is capable of complex learning, an evolutionary leap from the simple food/response pattern of a paramecium, but it is still only effective in the presence of the relevant environmental stimuli. It would not confer the ability to form mental images, and consequently does not indicate the presence of consciousness. From this unconscious basis, evolution, with the appearance of higher-order cortices, would have produced the 8 consciousnesses, enabling conscious beings, as we have seen, to learn and to memorize new knowledge quickly, even after only one experience.

Some of these consciousnesses are already present in reptiles, which have evolved a limbic cortex (anterior cingulate, posterior cingulate-precuneus, and insula) and higher-level sensory neo-cortices<sup>(51)</sup>. Hence, according to our reasoning, reptiles should also possess the corporeal consciousness furnished by the posterior insula, the emotional consciousness of the anterior insula, the object location consciousness of

the superior parietal lobe, and the perceptual consciousness of the superior temporal lobe. This would indicate, hypothetically at least, that these animals possess corporeal, physical, emotional, spatial and semantic memories. Further up the ladder, birds and mammals also have the frontal area BA 8, which drives extrapersonal motor consciousness and gives them the possibility to store memories of movements in space. This would explain why reptiles, birds and mammals are able to solve problems<sup>(3)</sup> that involve the ability to hold mental images<sup>(20)</sup>, while fish are not.

The BA 6 appeared for the first time in monkeys, providing peripersonal motor consciousness and memory of hand (or paw) movements. The subjective-motor consciousness of the Author, on the other hand, would not have evolved until the apes (e.g., chimpanzees), the first animals to possess an inferior frontal lobe BA 44-45-46<sup>(1)</sup>. Indeed, the great apes are able to recognize themselves in the mirror - presumably through an ability to compare their current movement with the mental image of that same movement. Therefore, subjective motor consciousness gives a being the feeling of being the Author of what is occurring, enabling episodic memory.

It was not until humans, however, that the subjective consciousness of being a spectator, or reflective self-awareness, evolved, along with the appearance of the inferior parietal lobe BA 39/40<sup>(48)</sup>. Reflective self-awareness is the perception of body position with respect to where the object is, and it gives us the feeling of being present in the environment. In fact, Povinelli<sup>(50)</sup> showed that between man and chimpanzee there are evident differences in cognitive abilities that go beyond the obvious difference in verbal communication. As a matter of fact, chimpanzees are unable to solve experimental problems that require the ability to refer to themselves as subjects of the scene. This self-awareness is thought to be necessary for autobiographical memory and give us the capacity to reflect upon ourselves (meta-consciousness). Through subjective consciousness, we are able to make assumptions about our own future and what other people are thinking. Hence, we have a theory of mind, because we can remember how we behaved in similar situations. The knowledge that the other thinks the same or something similar to ourselves is considered by most Authors to be an assumption of communication through language. Confirmation of the close link between consciousness and language is given by the fact that the areas of language in the left

cerebral hemisphere correspond to Broca's area and Wernicke's area. The former is made up of areas of the inferior frontal lobe and the latter of the superior temporal lobe and inferior parietal lobe<sup>(6)</sup> - all areas of the brain that are NCCs of some type of consciousness, at least according to the theory outlined herein.

## □ THE MIRROR NEURONS

The hypothesis that the NCCs are active both when they receive an external image and when a mental image is produced immediately brings to mind the mirror neurons studied by Rizzolatti et al.<sup>(53)</sup>. These researchers found that, in monkeys, mirror neurons are activated both when an action is executed, and when it is observed being executed by another. The data suggests that these neurons are also present in humans<sup>(36,46)</sup>, making it possible to speculate on our own ability to understand the actions of others and on how this would have allowed the emergence of sociality, and then language.

In my opinion, these mirror neurons belong to motor consciousness, which, as we have seen, is active when a particular movement is performed consciously and when it is merely imagined. Indeed, it has been demonstrated experimentally that mirror neurons are activated not only when you execute and observe a movement, but even when you imagine yourself making this movement<sup>(22)</sup>. Hence we can assume that when a monkey sees a movement accomplished, it creates a mental image of the same movement, as performed by itself.

Intriguingly, there is a surprising anatomical overlap between the proposed NCCs and areas considered part of the mirror neuron circuit<sup>(7)</sup>, which would lend weight to the theory that the mirror neurons studied by Rizzolatti and staff<sup>(53)</sup> are in fact the neurons of motor consciousness and the other 7 consciousnesses (which of course are activated simultaneously). Going one step further, we could call the NCCs of the 8 respective consciousnesses the mirror neurons of the corporeal emotional, perceptual, positional and subjective spectator consciousnesses, and the 3 motor consciousnesses.

## □ CONCLUSIONS

As we have seen, the NCCs have been specifically identified one by one by the characteristic neglect

caused by lesions in each area of the brain responsible for a particular consciousness, and by the fact that bilateral lesion each area completely prevents it from exerting its specific function (without affecting the other consciousnesses). What is more, fMRI studies confirm that these areas are active while carrying out the function that is severely impaired by their respective specific neglect and during conscious perception, and the same areas are damaged in Alzheimer's disease, which causes a loss of conscious autonomy.

As Damasio<sup>(14)</sup> suggested, there appear to be brain areas related to consciousness that act as points of convergence of both the image of the object and the emotions (or memory of the emotions) generated by the object. This idea, which may not necessarily be confined to emotional consciousness, seems to mesh neatly with the concept of mirror neurons, which may enable conscious animals, ourselves included, to build mental images or representations, an evolutionary advantage in terms of rapid learning and problem-solving by image-based reasoning.

Although we will never know what animals think, confirmation of the above may enable us to state that reptiles, birds and mammals are aware of their body and a sequence of meaningful images, but they are not aware of being the doers those actions. Monkeys, on the other hand, are aware of making certain movements, but they have no subject consciousness of themselves as the Authors of such action, unlike the apes, in whom this awareness has evolved. According to this theory, however, it is we who stand alone, conscious of our subject spectator status in the Theatre of Consciousness.

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