COGNITIVE NEUROSCIENCE AND ANIMAL CONSCIOUSNESS

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Abstract

The problem of animal consciousness has profound implications on our concept of nature and of our place in the natural world. In philosophy of mind and cognitive neuroscience the problem of animal consciousness raises two main questions (Velmans, 2007): the distribution question ("are there conscious animals beside humans?") and the phenomenological question ("what is it like to be a non-human animal?").

In order to answer these questions, many approaches take into account similarities and dissimilarities in animal and human behaviour, e.g. the use of language or tools and self-recognition in a mirror (Allen and Bekoff, 2007); however, behavioural arguments do not seem to be conclusive (Baars, 2005). Cognitive neuroscience is providing comparative data on structural and functional similarities, respectively called "homologies" and "analogies". Many experimental results suggest that the thalamocortical system is essential for consciousness (Edelman and Tononi, 2000; Tononi, 2008). The argument from homology states that the general structure of the thalamocortical system remained the same in the last 100-200 million years, because it is neuroanatomically similar in all the present and past mammals, and it did not change much during phylogeny (Allen and Bekoff, 2007). The argument from analogy states that the key functional processes correlated with consciousness in humans are also present in all other mammals and many other animals (Baars, 2005). These processes are information integration through effective cortical connectivity (Massimini et al., 2005; Rosanova et al., 2012), and elaboration of information at a global level (Dehaene and Changeux, 2011).

On this basis, the "Cambridge Declaration on Consciousness" stated that all mammals, birds, and many other animals (such as octopuses) possess the neurological substrates of consciousness (Low et al., 2012).

Conscious experience is private (Chalmers, 1995; Nagel, 1974), therefore the answer to the phenomenological question may be impossible. Nevertheless, cognitive neuroscience may provide an answer to the distribution question, showing that conscious experience is not limited to humans since it is a major biological adaptation going back millions of years.

1. Two Questions on Animal Consciousness

Consciousness is the most intimate and patent aspect of the experiences we undergo daily. From when we wake up to when, lying in bed, our senses are blurred and we sink into sleep, consciousness is a matter of fact, and so it seems perfectly obvious to us. In our lives we are spontaneously able to establish whether other people are conscious or not: we recognize when someone faints from fear, we are aware of pathological conditions characterized by the loss of consciousness such as coma, and we rely on the anaesthetist before an important operation so that the drugs administered erase, together with consciousness, all the pain and the unpleasant memories of the surgery.

Despite this daily competence, it is hard to explain the criteria we use to determine whether an individual is actually conscious or not. Most of the times we just have to rely on observed behaviour: individuals who interact with the exterior environment and with other people are evidently conscious, especially if they are able to react consistently to stimulations and respond to our questions in a meaningful way. However, an objective judgment given from an external point of view, from the "third person", is not enough: would we say that sleepwalkers are conscious just because they interact with the external environment? In an intuitive and simplistic way, we could say that individuals are conscious only if *it is something to be* them. Given that during deep dreamless sleep, or under general anaesthesia, we do not feel anything, we could say that in such cases consciousness disappears completely.

However, the ability to evaluate consciousness might go beyond the limits of our own species: are animals such as dogs and cats conscious, too? They show complex behaviour, we empathize with them, we believe they understand our emotions and our feelings and many times we even talk to them. Are animals phylogenetically more distant from us (such as birds and fishes) conscious as well? Where does the boundary lie between animals that are conscious and animals that are not? With respect to these questions, our intuitions are useless and unfit, and they find us totally unprepared and unable to provide even the slightest response. Precisely

because of the elusiveness of consciousness, even scientists and philosophers are in deep water when considering these issues.

The problem of animal consciousness has profound implications for the concept of nature and the place of man within it. For a long time, anthropocentrism has been characterizing the view that humankind has of itself as a privileged species at the top of the so-called *Scala naturae*, as was considered to be the only being endowed with intellect, soul or simply mind and consciousness.

The problem of animal consciousness comes up again, now more than ever, in the philosophical and scientific debate, bringing along several implications about the centrality of humankind in the natural world as well as ethical implications. In fact, many animal species are used in research and industry, and many of them are subject to intensive farming. The assumption that our ethical obligations towards animals depend on their mental life is quite common and well-grounded in intuition (Farah 2008), and the ethical issue concerning animals is of primary importance. In fact, the rejection of the hypothesis of animal consciousness seems less and less grounded, given the increasing amount of scientific models of affective and emotional experiences both in humans and other animals (Panksepp 2005).

In recent years, two fundamental questions about animal consciousness have been at the centre of a big debate, involving both philosophy of mind and cognitive neuroscience (Allen and Beckoff 2007). The first is the so-called *distribution question* (DQ):

(DQ): Are there conscious animals beside humans?

Many animal species share the ability to respond to environmental stimuli with intelligent behaviour, and the organisms phylogenetically closer to *Homo sapiens* share with us several anatomical structures. However, there is no objective criterion available for determining with certainty whether there are other conscious animals besides humans. Consciousness might in fact be a common feature of many species, including the class of mammals, or the entire group of vertebrates; nevertheless, without a reliable criterion we cannot establish any useful test to distinguish between conscious and unconscious organisms.

Being conscious is not just being awake and reactive, or being able to respond to environmental stimuli and show intelligent behaviour. Being conscious also means having experience of the world, of the actual shape of a flower, the colours in the sky, the smells and flavours of food; being conscious means having desires, feeling pain from the wounds, feeling fear of predators, and so on. Thus, there is a second important question on

animal consciousness that focuses on the qualitative aspects of conscious experience and is expressed in the form of the so-called *phenomenological question* (PQ):

> (PQ): Can we know what, if anything, the experiences of those animals are like?

Many philosophers think that consciousness is the last surviving mystery, and that science cannot face up to the problem of consciousness because of its subjective and phenomenal aspects. According to Chalmers (1995), conscious experience constitutes the very and only *hard problem* that science has to tackle. Both the *hard problem* and the PQ are based on the concept of *phenomenal consciousness*, introduced by Ned Block (1995) and widely debated in the philosophy of mind. This concept refers to the subjective and qualitative nature of each experiential state of consciousness, whether it belongs to humans or not. What does a wasp feel when glancing at the colours of a flower? What does a cow experience while looking into the eyes of the farmer who milks her daily? Can we make a comparison between the conscious and subjective experience of being a man with the experience of being another animal?

These questions are loaded with both metaphysical and ethical implications, and these issues constitute the core of deep philosophical reflections. The DQ relates to the issue of the centrality and superiority of mankind in the natural world at its core and the question admits two contrasting answers: "Yes, there are conscious animals besides humans" or "No, there are not".

Two types of theories about the distribution of consciousness in nature have been proposed in order to answer the DQ (Velmans 2007), namely *discontinuity* and *continuity* theories. *Discontinuity theories* state that consciousness emerged at a certain stage of the phylogeny. The models that equate this stage with the evolution of the genus *Homo* usually reply negatively, claiming that only humans are endowed with consciousness and that the distribution of consciousness is discontinuous, since it belongs only to them. The models which instead place such a gap elsewhere are inclined to reply in a positive way, claiming that in nature there are many living organisms endowed with consciousness. According to this view, this phenomenon has emerged at a specific stage of phylogeny and it is a shared feature of either the entire *taxon* of vertebrates, or the sole group of mammals, or the primates alone, depending on the particular view. In general, discontinuity theories share a vision of nature that presents jumps and in which the living organisms endowed with consciousness are sharply divided from all the others. As we will see in the following paragraphs,

many discontinuity models have recently been proposed.

On the contrary, *continuity theories* always reply "Yes, there are conscious animals besides humans"; indeed, they think there are plenty of them. Continuity theories argue that consciousness is a property that has always characterized living beings, and that it is distributed in different degrees throughout the natural world. These theories often embrace a form of *panpsychism*, arguing that consciousness is a fundamental property that characterizes, to a certain extent, even matter itself, albeit at low and irrelevant levels, and that it co-evolves in complexity with matter and its aggregates (Chalmers 1995; Velmans 2007; Whitehead 1929).

Among the many proposals aimed at addressing the distribution question, some are based on the identification of similarities and dissimilarities in the behaviour of humans and other animals, but behavioural observations do not seem to be a reliable and satisfactory criterion (Baars 2005). However, the two questions about animal consciousness have caused even more discussion since additional non-behavioural arguments appeared in the scientific and philosophical debate. In recent years, cognitive neuroscience has been shedding light on the neural structures essential for consciousness in humans, raising several questions about the distribution of consciousness in nature and strongly influencing the debate on animal consciousness. A new neuroscientific line of argument is based on the similarities found at the neural level in species different from *Homo sapiens*, and it is deeply connected with the identification of those structures and processes that constitute the neural substrate of consciousness in human beings.

In this article, I will firstly discuss the most important examples of behavioural arguments and I will argue that such arguments are unsatisfactory. Then, I will show how cognitive neuroscience has contributed so far to the study of animal consciousness, and I will show the conclusions that can be drawn in the light of these findings. Finally, I will argue that cognitive neuroscience is the only reliable base to answer philosophical questions such as the distribution question. Nevertheless, neuroscientific progress cannot lead to the solution of philosophical issues related to subjective conscious experience, since it cannot contribute to the formulation of an answer to the phenomenological question.

2. From Behaviour to Consciousness

Whenever we have to give a reason why we consider a human conscious as opposed to, say, a computer, we most likely begin with noticing the following: a human being is capable of complex behaviour

that goes well beyond the mechanical and automatic processes a computer is able to carry out with flawless precision. The observed behaviour is one of the most important criteria, so much that artificial intelligence research, since its origins, was based on the idea that building a computer able to implement typically human behaviours such as language or reasoning would correspond to recreating mental processes similar to those that occur in the human brain. Indeed, one of the fathers of artificial intelligence, Alan Turing, considered the behavioural criterion as the most reliable basis for developing a test of machine intelligence, now known as the *Turing test* (Turing 1950). In the same way, the debate has always been focused primarily on behavioural observations also with respect to the issue of animal consciousness, and many arguments based on the similarities between the behaviour of humans and other animals have been proposed (Allen and Beckoff 2007).

One of the most evident abilities that characterize humans is the use of language. Our species, through the use of historical-natural languages, has been able to communicate and build the characteristic complex network of social ties. Some philosophers, such as Descartes, argued that the use of articulate languages is a clear sign of the ability to reason, and therefore constitutes the basis for inferring the presence of consciousness in other living beings (Descartes 1984-91). Humans, however, are not the only animals that use language. There have been many instances of non-human animals able to use a language in order to communicate. Professor Irene Pepperberg spent decades studying the linguistic skills of an especially talented African grey parrot (*Psittacus erithacus*). The grey parrot Alex showed many similarities with the use of language typical of human beings, in stark contrast to the Cartesian idea that animals are not equipped with language, or are only capable of a very limited use of it. Alex had a vocabulary of a hundred and fifty words (similar to that of a two-year old child), he could identify fifty different objects and recognize quantities up to six, he could distinguish seven colours and five shapes, he understood the concepts of zero and said "I want to go back to my cage" when he was tired (Pepperberg 2002). Linguistic skills have also been found in many other animal species besides African grey parrots, in the form of the capacity to use a modified sign language or symbols of the Yerkes Laboratory keyboard system (chimpanzees, bonobos), or alarm calls (lemurs, vervet monkeys, social mongooses and prairie dogs) (Griffin and Speck 2004).

The use of language, although largely correlated with the complex cognitive processes *Homo sapiens* is capable of, might not be certain evidence of the presence of consciousness. In fact, discussing the example

of parrots, Descartes (1984-91) argued that any process put in place by these and other animals is in principle conceivable as purely mechanical. Parrots, in this case, could talk without being aware of it, and this would also explain the limited use of language that distinguishes all other species compared to humans.

Besides the use of language, the use of tools is often considered a second indication of intelligence and complex mental faculties. Once again, the animal kingdom presents many examples of species that show this capability. Among the various species, certain crows represent perhaps the most interesting example. New Caledonian crows (*Corvus moneduloides*) show the ability of "crafting" tools, such as wooden hooks, that they subsequently use to probe for invertebrates in crevices. In several experiments it was observed that these crows, when placed in proximity of a 30-cm-long cylindrical container with a single opening and containing a favourite food, are able to immediately retrieve one of the sticks available in the cage and, holding it with their beak, slide it into the cylindrical tube to extract the food (Hunt and Gray 2004). In nature, the crows insert sticks into cavities and drag out the preys that would be difficult or impossible to flush out otherwise. If faced with a vertical cylinder containing a bucket of seeds, such crows are able to grasp with their beak a metal stick, bend it leveraging on one end so as to fabricate a hook, and use it to extract the bucket of seeds from the cylinder (Weir, Chappell and Kacelnik 2002).

Despite the ability to communicate and use languages or tools, further types of behaviour might seem to be solid evidence of the presence of consciousness in non-human animals. Less than fifty years ago, in order to ascertain the presence of self-awareness and meta-consciousness, Professor Gordon Gallup devised the so-called "mirror test". It has long been known that species phylogenetically close to *Homo sapiens*, such as chimpanzees, are very attracted by the use of mirrors, and contemplate themselves in their own reflected image. Starting from this evidence, Gallup has developed the mirror test in order to determine whether these animals are actually able to recognize themselves in the reflected image, or they are interested in it only because they recognize the shape of one of their own kind. For this purpose, Gallup put several chimpanzees in front of a mirror, leaving them contemplating their own reflected image for a few days. After an initial period in which the animals responded by attacking the image or getting frightened, they eventually got used to it and began to simply contemplate the reflections in the mirror. At that point, Gallup marked the bodies of the animals with odourless paint , in a place visible only in the mirror. The animals showed evidence of understanding that the stain was on their own body, and would in fact turn

the stained part of the body towards the mirror for a better look and inspected the same body part with a limb while looking in the mirror (Gallup 1970). According to Gallup, mirror self-recognition is an indicator of self-awareness. Furthermore, he claims that the ability to infer the existence of other individuals' mental states (namely, having a "theory of mind") is a by-product of self-awareness. He describes the connection between self-awareness and theory of mind by saying that, being self-aware, an individual is in a position to use his own mental experience to infer and model the existence of comparable mental and intentional processes in others (Gallup et al. 2002).

It is clear that much additional work will be required before a complete report. However, a list of the animals that have passed the mirror test so far includes humans (from the age of 18 months) as well as all the great apes such as chimpanzees, gorillas, bonobos and orangutans (Miller 2009), some marine mammals such as bottlenose dolphins (Marten and Psarakos 1995) and orca whales (Delfour and Marten 2001), but also elephants (Plotnik, de Waal and Reiss 2006) and European magpies (Prior, Schwarz and Güntürkün 2008).

Thus, many approaches take into account similarities and dissimilarities in animal and human behaviour. Nonetheless, behavioural arguments do not seem to be conclusive (Baars 2005). Even though behaviour might appear as a reliable criterion for assessing the state of consciousness in humans as well, recent developments in cognitive neuroscience have shown that there is no substantial proof. For instance, neurology and coma science have provided many examples in which the assessment of the level of consciousness is a puzzling clinical issue. This is the case of non-communicative patients who, despite being perfectly aware, are unable to prove it by means of any observable behaviour. Indeed, neuroscience has recently started providing methods and tools for assessing consciousness that are not behaviour-based (Rosanova et al. 2012). These tools are proving their usefulness in the diagnosis and treatment of disorders of consciousness (and related conditions) such as the locked-in syndrome, and for the reasons outlined so far they might be very useful in the study of animal consciousness as well.

3. Neuroanatomy and Neurophysiology of Human Consciousness

The study of animal consciousness is the centre of a renewed interest because of the appearance of a new series of arguments. These arguments are based not on the observed behaviour, but on the animals' brain

structures and processes, which are similar to human ones, that can be investigated using the tools of neuroscience. Cognitive neuroscience is gradually leading to a better understanding of the neural correlates of consciousness in humans and, in doing so, it is offering at the same time the opportunity to start investigating consciousness in other animals on a completely new basis.

In recent years, several theoretical and experimental models attempted to identify the structures and processes responsible for consciousness in humans. On the one hand, it is generally believed that the basic structure for the emergence of consciousness is mainly the thalamocortical system as a whole, with a specifically important role played by the prefrontal, cingulate and parietal cortices (Edelman and Tononi 2000; Laureys and Tononi 2009). On the other hand, besides anatomical structures, the fundamental processes of consciousness are cortical connectivity through information integration (Tononi 2008; Edelman and Seth 2009) and elaboration of information shared and processed at a global level (Dehaene and Changeux 2011; Tononi and Koch 2008).

The 100 billion neurons that constitute the central nervous system are organized into different structures that are important for the emergence of consciousness. Considering only the cerebral mass and the number of neurons, for example, one could think that consciousness emerges from the interaction of an exorbitant number of cells that are able to exchange electrical signals by means of an even greater number of intricate synaptic connections. However, extensive neurological evidence has shown that consciousness does not depend exclusively on the number of neurons. The 100 billion neurons contained in the central nervous system are divided into two distinguishable structures: the thalamocortical system and the cerebellum. The cerebellum is a single body with a complex structure and consists of about 70 billion neurons, while the thalamocortical system is composed of about 21 billion nerve cells (Pakkenberg et al. 2003; Llinàs, Walton and Lang 2004). Despite their similarity, these two structures contribute in a very different way to consciousness because, contrary to the cerebellum, the thalamocortical system is crucial in supporting consciousness (Edelman and Tononi 2000). The thalamocortical system is composed of the thalamus, a deep structure located in the diencephalon, and the cerebral cortex, the thin layer of neurons that constitutes the outer (and most recent) part of the telencephalon in vertebrates. This structure is considered responsible for complex cognitive processes such as memory, perception, thought, and language. As many cases studied by clinical neuropsychology demonstrate, injuries to this structure of the central nervous system can cause the loss of cognitive functions such as

perceptive abilities, memory, thinking and reasoning, as well as the complete loss of consciousness (Laureys and Tononi 2009). Even a slight damage to some areas of the thalamocortical system (such as the brainstem or the ascending reticular activating system) can cause a total loss of consciousness, leading the subject into a state of coma, vegetative state or even brain death (Vincent 2000).

The cerebellum too is responsible for important functions, such as motion control and motor learning, but this structure does not seem to play any significant role with respect to conscious experience. In fact, as a result of "cerebellectomy", a surgery which consists in the total removal of the cerebellum, patients show serious deficits in posture and gait control, linked to the impaired control of limbs and eye movements (cerebellar ataxia); however, none of the cognitive functions seem to be damaged in these patients (Tononi 2008). In fact, the cerebral cortex and the cerebellar cortex have a very different structural organization: the modules of the cerebral cortex, as highly specialized, are abundantly connected to each other, while individual modules in the cerebellar cortex tend to be activated independently of one another, with little long-range interaction possible between distant modules (Tononi 2004, 2008). This shows that the integration of information through a complex network of long-range connections is fundamental for the emergence of consciousness.

Recently, Stanislas Dehaene proposed the "Global Neuronal Workspace" model in order to explain which fundamental property is responsible for the emergence of consciousness from the thalamocortical system. Dehaene and his colleagues argue that the thalamocortical system is responsible for the emergence of consciousness as composed of a particular structure, the "global neuronal workspace", consisting in a group of cortical pyramidal neurons with excitatory function and with long-range cross-cortical axons. A high density of this cell type is located in the prefrontal, cingulate, and parietal cortices, and, according to this model, together they would form a neuronal "workspace" connecting a large number of peripheral processing systems and specialized modules, which otherwise always work isolated and on a subconscious level (Dehaene and Changeux 2011). In this model, the prefrontal cortex is a root node of a global network formed by long-distance synaptic connections. This assumption is confirmed by the fact that the prefrontal cortex is connected with a number of very different sensory areas through cortico-cortical connections, and this massive two-ways connectivity justifies the important role played by this particular structure in the hypothesis of a global workspace connecting many areas of the thalamocortical system and supporting consciousness.

There is very strong evidence that the thalamocortical system supports consciousness. However, although the presence of such brain structures is a necessary condition, it is not yet sufficient in attributing consciousness to a subject. We are witnesses to the fact that every night consciousness disappears when we fall asleep in a dreamless sleep, but of course the anatomy of our nervous system does not change from day to night. The changes responsible for this daily loss of consciousness are instead due to the availability of neurotransmitters and the particular activity pattern of the billions of neurons that form the thalamocortical system. As shown by electroencephalographic (EEG) measurements, during stage 4 of NREM sleep the firing rate of many cortical and sub-cortical neurons is characterized by oscillatory synchrony and bistability: neuromodulatory changes (e.g. low acetylcholine) trigger a modification in the intrinsic and synaptic conductance, therefore cortical neurons enter every few hundred milliseconds in a hyperpolarized down-state and cannot sustain firing for a short period of time. Shortly afterward, they inevitably return to a depolarized up-state and start their action potential activity again (Steriade, Timofeev and Grenier 2001). According to Giulio Tononi's "Integrated Information Theory", consciousness fades in deep sleep because of a decrease in the capacity to integrate information that characterizes the whole thalamocortical system in this state. This capacity is greatly reduced in deep NREM sleep because the thalamocortical system breaks down into causally independent modules and shrinks its repertoire of possible responses, therefore losing effective cortical connectivity and the capability to elaborate high amounts of information at a global level (Tononi and Massimini 2008; Massimini et al. 2005).

Moreover, the importance of the thalamocortical system is also shown by the fact that several consciousness disorders are due to neurological damage to this structure. The most common disorders that produce at least transient coma are structural brain lesions (cortical or white matter damage, and brainstem lesions), metabolic and nutritional disorders, exogenous toxins, central nervous system infections such as septic illness, seizures, temperature-related disorders (hypothermia or hyperthermia), and trauma (Laureys and Tononi 2009). All these injuries or conditions interfere with the ascending reticular activating system (ARAS). The ARAS plays a central role in disorders of consciousness because it is the system responsible for the arousal function. As it is represented by structures in the brainstem, the diencephalon and projections to the cerebral cortex (Vincent 2000), the state of unarousable unconsciousness named "coma" is the effect of an impairment in this system (Laureys and Tononi 2009). In addition, recent studies show impaired functional

connections between distant cortical areas and between the thalami and the cortex in vegetative patients (Laureys et al. 2002). More importantly, these studies suggest that a restoration of this cortico-thalamo-cortical interaction causes a recovery of cortical effective connectivity (Rosanova et al. 2012) and therefore the recovery of consciousness (Laureys et al. 2000).

Given the base these findings constitute, is it possible to deal with the problem of determining the distribution of consciousness in nature? How confident can we be in determining, on the chronological and phylogenetic tree of life, the position of the line that separates conscious organisms from unconscious ones?

4. Homologies and Analogies

Cognitive neuroscientists have provided comparative data on structural and functional similarities between different species, respectively called "homologies" and "analogies". Homologies are phenotypical characters, namely bodily structures, similar in different species because they were inherited from a common ancestor possessing those characters. Analogies are phenotypical characters similar in different species because of convergent evolution instead of common ancestry. These characters evolved independently but are thought to be analogous for the similar function they play and were selected for.

The arguments based on neural homologies state that the general structure of the thalamocortical system remained the same in the last few hundred million years, for it is anatomically similar in all currently existing and past mammals and did not change much during phylogeny. Moreover, these arguments state that the key functional processes correlated with consciousness in humans are also present in all other mammals (Edelman, Baars and Seth 2005). According to this hypothesis, consciousness is a biological adaptation dating back many millions of years (Baars 2005).

Even on the basis of neuroscientific arguments, however, it is still very hard to formulate a precise answer to the question about the distribution of consciousness in the natural world. To this day, many hypotheses have been proposed about consciousness in non-human animals, covering different *taxa* such as mammals, vertebrates and invertebrates as well.

According to Baars (2005), the comparison between the thalamocortical structures of man and those of other mammals suggests the possibility of attributing consciousness to this whole category of living organisms: all mammals, in fact, have a highly developed thalamocortical system. The study of cranial fossil remains and gene conservation across species

suggests, moreover, that the fundamental structures of the thalamocortical system have not undergone major changes over the last 100-200 million years.

Furthermore, it is possible to detect in all mammals the same EEG activation patterns observed in man, so that the results of EEG studies on mammals are often directly applied to humans. During the waking state, the EEG of all mammals shows low-voltage, fast and asynchronous neural activity throughout the whole thalamocortical system. On the contrary, during deep sleep the EEG reveals slow, synchronous and high-voltage activity. Moreover, the wake-sleep cycle has many similarities among all mammals: with a few exceptions such as whales, most mammals have both NREM sleep and REM sleep—a stage of sleep characterized by the rapid and random movement of the eyes and the higher presence of dreams. The variation of electrical brain activity in the transition between waking and sleep states is one of the features that humans and other mammals have in common: in humans synchronous oscillatory activity corresponds to the lack of consciousness, as shown during deep sleep, general anaesthesia and in other pathological conditions such as coma and epileptic seizures, and this kind of activity contrasts sharply with the presence of consciousness during the waking state. The distinction between waking and sleep therefore constitutes one of the most reliable criteria to confirm the presence or absence of consciousness in humans and other animals (Baars 2005).

Homologies are necessarily remoter in non-mammals, which do not share the mammalian complex thalamocortical system. Avian species exhibit a broad range of complex behaviours, like the use of tools by New Caledonian crows, but what do neuroanatomical studies tell us about it? The overall organization of the central nervous system can be traced back to some 520 million years ago and it seems a common feature of some lower vertebrates such as reptiles, as well as birds and mammals (Smith 1999). Birds have anatomical structures that represent homologies and analogies compared to the thalamus and to the cerebral cortex of mammals: in the avian dorsal pallium, for example, the somatomotor circuitry seems a clear homology of the mammalian basal ganglia-cortico-thalamic loop (Medina and Reiner 2000). Moreover, they have waking EEG patterns similar to those detectable in mammals during the waking state (Edelman et al. 2005). Nevertheless, EEG patterns of avians during sleep are different from those of mammals, although their sleep is characterized by both REM and NREM sleep (Ayala-Guerrero 1989). Since reptiles show less homologies and analogies with brain structures and processes that are fundamental for consciousness in humans and other

mammals, it is unclear whether reptiles are capable of conscious awareness. However, mammalian and avian species show homologous structures or similar analogous arrangements, suggesting the hypothesis that consciousness emerged approximately 300 million years ago, probably twice and in an independent way, after the divergence of the two reptilian lines that led alternatively to birds and mammals (Kardong 1995; Edelman et al. 2005).

Further studies about the possibility of attributing at least primary consciousness to other organisms belonging to invertebrate species are currently being discussed, and many of them focus on cephalopods like the octopus (Merker 2005). Octopuses (*Octopus vulgaris*) possess refined cognitive capabilities. They show the ability of classifying different shaped objects in the same manner as vertebrates such as rats do. They show also memory, learning and complex decision-making skills. Cephalopods like the octopus have complex nervous systems similar to those of some vertebrates, at least with respect to the number of constituent neurons alone: the relative brain size of many cephalopods exceeds that of many lower vertebrates (Hanlon and Messenger 2002). Nevertheless, contrary to birds, cephalopods show a different organization of the nervous system that poses many problems in identifying the necessary structures underlying consciousness (Edelman et al. 2005). Moreover, a significant fact is that many cephalopods show EEG patterns akin to those present in awake and conscious vertebrates (Bullock and Budelmann 1991), and they are the only invertebrates in which this was demonstrated, besides fruit flies.

So far, experimental evidence has been insufficient to draw any definitive answer to the DQ. However, as we increase our knowledge we may be able to make more profound and reliable predictions that apply not only to some birds and reptiles, but also to large-brained invertebrates and possibly to many other species (Seth and Baars 2005).

5. The Cambridge Declaration on Consciousness

Recently, the hypothesis of animal consciousness has given rise to a huge debate. Philosophers and scientists of every background and orientation are facing up to the related theoretical issues, and they are discussing the experimental evidence that has gradually accumulated. However, the problem of animal consciousness might not remain unresolved. In fact, as I showed so far in this paper, consciousness studies have increased dramatically over the past few decades. A huge amount of brand new data is available today and might shape reflection on this issue.

2012 was undeniably an important year for the studies on animal consciousness because it witnessed an important event. A group of eminent scientists from different countries met and signed a document of central importance for the animal consciousness debate: the "Cambridge Declaration on Consciousness" (Low et al. 2012). The team of scientists included neuroscientists, neurophysiologists, neuroanatomists, neuropharmacologists and computational neuroscientists. The Declaration was proclaimed in Cambridge, UK, on July 7, 2012, at the Francis Crick Memorial Conference on Consciousness in Human and Non-Human Animals, at the Churchill College, University of Cambridge, by Philip Low, David Edelman and Christof Koch. In this two-page document, these prominent neuroscientists summarized many experimental observations and made several assertions that can be now unequivocally claimed about the matter of animal consciousness.

Firstly, the Declaration states that new techniques are available for the study of the neural correlates of consciousness in humans and non-human animals, and these studies have shown that it is possible to identify homologous brain circuits whose activity correlates with conscious experience, and which can be selectively facilitated or disrupted to determine whether they are necessary for conscious experience or not. According to the authors, a lot of evidence indicates that non-human animals possess the neuroanatomical, neurochemical and neurophysiological substrates that sustain consciousness and the ability to carry on complex intentional behaviours.

The neural circuits that support attention, the sleep-wake cycle and decision-making are found in many animals, such as insects and cephalopods, and date back to the invertebrate radiation. Birds, in particular, represent a remarkable case of parallel evolution of consciousness, because they show evidence of human-like levels of consciousness in their behaviour, supported by strong similarities in the neurophysiological processes and neuroanatomical structures of their nervous system.

In conclusion, the subscribers of the "Cambridge Declaration on Consciousness" clearly state the following:

> Convergent evidence indicates that non-human animals have the neuroanatomical, neurochemical, and neurophysiological substrates of conscious states along with the capacity to exhibit intentional behaviors. Consequently, the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness. Non-human animals, including all mammals and birds, and many other creatures, including octopuses, also possess these neurological substrates. (Low et al. 2012, 2).

6. What Is It Like To Be a Bat?

The phenomenological question focuses on the concept of "phenomenal consciousness", namely the subjective and qualitative aspects of conscious experience, on the "first-person" point of view that we would not ascribe, for example, to a robot only because it seems capable of complex calculations and responses. What is it like to be a non-human animal? It is hard to say, first of all because animals do not talk and cannot tell us, or at least because we do not know how to communicate with them. In 1974 Thomas Nagel put the emphasis on this aspect in his famous article *What is it like to be a bat?*, in which he argued that conscious experience is different from every other property of the natural world because it is private. According to the author, even granting the fact that other animals might feel something, we will never know what it is like to be one of them. Indeed, even if one could imagine it, he would know what it is like to be a bat for a man, and not what it is like to be a bat for a bat (Nagel 1974). The privateness of others' mental experience outlines a limit so clear and insurmountable that it could cast doubts on the very fact that it is really something to be another animal.

However, this privateness does not only characterize the mental states of non-human animals, but also the conscious experience of our own fellow conspecifics. The philosophical problem of "other minds" leads to the sceptical conclusion that, by observing the behaviour of other human beings, we could never conclude that they, too, have a conscious mind (Nagel 1986). Only the subject himself can be sure of possessing a mind and of being conscious, as he alone has privileged access and experiences first-hand the fact of being conscious. For this reason, the privateness of conscious experience and the problem of other minds lead to two alternative ways to answer the question: the first is the sceptical and solipsistic conclusion that each subject believes to be the only one having for sure a conscious mind, while the second consists instead on relying on an inference to the best explanation admitting that, despite the unbridgeable gap between the first and the third person point of view, there are good reasons to believe that there are other conscious minds as well besides that of the subject himself.

If you accept the second view, and this is the most interesting point, the conscious experience of other humans would not seem more accessible than that of non-human animals. Therefore, the reasons we have to infer that our fellow humans are conscious, since they share the same anatomical structures and implement the same types of behaviour, constitute the basis for inferring that many non-human animals are equally

conscious. Thus, the privateness of conscious experience does not limit the possibility of answering the question about the distribution of consciousness in the natural world.

It is clear that much additional work will be required in order to identify which (and to what extent) non-human animals are conscious, but it seems that the distribution question will have in any case a positive answer. However, the privateness of conscious experience will probably remain an insurmountable limit to our understanding of what it is like to be such other animals, leaving the phenomenological question completely unanswered.

7. Conclusions

The problem of animal consciousness is perhaps one of the most relevant issues that philosophy of mind and cognitive neuroscience are facing today. The new research paradigm based on neuroscience has achieved important results in just a few decades, and this seems to be just the beginning of an era full of new and astonishing results. Cognitive neuroscience is broadening our understanding of the neural basis of consciousness in man, through the study of consciousness in normal conditions as waking and sleeping, and it is shedding light on which mechanisms regulate its disappearance in pathological conditions such as coma, providing a basis to improve the diagnostic process and the clinical treatment of such diseases and conditions.

In the past, the debate on animal consciousness was mainly based on behavioural observations, and many arguments for or against animal consciousness were grounded in behavioural similarities and dissimilarities of other animals with respect to human beings. As we have seen, human consciousness studies today, constitute the basis for a new type of arguments, based no longer on behavioural observation but on the direct comparison between different kinds of anatomical structures and brain processes that, in humans, are known to give rise to consciousness. The neuroscientific research of interspecific homologies and analogies is suggesting that man is not the only animal endowed with consciousness. The basic structure for its emergence, i.e. the thalamocortical system, was already present for about 150-200 million years before *Homo sapiens* appeared, and characterizes the entire class of mammals. Moreover, in many animals we can find the same brain processes that are essential for consciousness in man (such as the presence of electrical brain activity in distinct stages of waking, NREM and REM sleep), and this evidence suggests that animals distant from man from a phylogenetic point of view,

like birds, or even invertebrates such as cephalopods, possess at least a primary form of consciousness.

Given that conscious experience is private, we cannot explain what it is like to be another animal. Therefore, answering to the phenomenological question may be impossible in principle. Nevertheless, cognitive neuroscience may provide an answer to the distribution question, showing that conscious experience is not limited to humans but is a major biological adaptation going back many millions of years. The further progress of neuroscience will clarify how wide we should consider the class of living organisms endowed with consciousness. However, at the moment the evidence is strong enough to consider all mammals and some vertebrates such as birds as fully belonging to that class. Only future research and the synergy between philosophy and cognitive neuroscience will eventually explain the evolutionary history of consciousness, showing a discontinuity in its distribution, if it emerged at a precise stage of phylogeny, or showing its continuity across the natural world. Therefore, from now on, cognitive neuroscience will probably represent the base for the debate on animal consciousness. As the "Cambridge Declaration of Consciousness" argues, many conclusions about animal consciousness can already be stated unequivocally, and further data and experimental evidence will foster even more—and on a scientific basis—the ethical and philosophical debate on the relationship between humans and other animals.

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