THE EMERGENCE OF REASON IN THE ORIGINS OF MANKIND NEUROLOGY AND PALEOANTHROPOLOGY

FRANCISCO MORA
Human Physiology. Universidad Complutense de Madrid, Spain

CAMILO JOSÉ CELA CONDE
Human Systematics Laboratory. Balearic University (UIB), Spain

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Introduction: Origin of reason from neurology and paleontology

In the first three sessions of the seminar we have with no doubt addressed relevant issues to explain the evolutionary origin of reason. It is clear that human senses (produced in the evolution of animal sensorial systems) make us perceive a «world of structures or systems». Therefore, the origin of human reason relates to representations created in the mind to adapt to an objective and «systemic» reality (Poli). Nickel's contribution has had a positive, fully manageable result in the dynamics of the seminar: reason, especially mathematical reasoning in the set of formal sciences, is born of the free creativity of human mind. Reason produces «formal worlds». But reason is part of a natural being (man) and we must explain why reason has the power to create formal worlds. The discussion raised the alternative of an *a priori* origin (say, in the Kantian tradition) and of an *a posteriori* evolutionary origin. According to the latter hypothesis reason should have arisen from a natural evolution (in adapting to a world of objective structures). This adaptation would be driven by its own dynamics to make human reason able to imagine formal worlds in a creative and free mind activity.

Harald Walach opened a new perspective to consider the origin of reason: the *principle of complementarity* applied to psychology. Human beings not only «sense» a certain classical world of systems and structures, but also «sense» a world of a unified and holistic experience and indetermination. The result is immediate: reason should be considered not only having been produced by functional adaptation to a deterministic structural world (a type of reason rather evident on classical physics), but also by functional adaptation to a holistic world (a type of reason verifiable in the ordinary mind and the development of the quantum image of reality in science). Finally, in the third session of the seminar, Professor Manuel Curado, following an epistemological reflection based on the nature of reason, held the thesis that concludes by considering their evolutionary origin (an evolutionary theory of reason). Reason is also free and creative, but it has been produced by the logic of a natural evolutionary process in which living beings have to adapt to an objective world that imposes its constraints.

The internal logic of the seminar sessions allows us to understand the new thematic of the contributions of Professors Francisco Mora and Camilo José Cela Conde. We had not yet addressed a key aspect, which can be attributed in principle to be a causal factor in the process that produces the evolutionary emergence of reason. We refer to the human brain (nervous system) as a causal factor of reason (and of human behavior in general). In another level we could say the same on animal brain and animal behavior, especially on cognitive animal behavior.

Mora's presentation provides an overview of our current knowledge of the evolutionary process. This process has led animal species to develop a nervous system and a brain, while showing that the brain is the organ that produces the animal and human mental life. Reason is a higher mental activity of the brain. For this, the brain activates a series of structures, patterns or neural circuits that produce rational activity of our mind. All that (emotional, rational, volitional life, in its profound unity) occurs as a result of the brain's functions and therefore, as Professor Mora says, «man is his brain».

Camilo José Cela Conde does agree with Mora about evolutionary neurology: the birth of animal and human behavior can be attributed to the parallel growth and complexity of the nervous system and of the brain. This allows us to understand evolutionary changes in hominids and in early humans going from the *Australopithecus africanus* to *Homo erectus*, *heildelbergensis*, *neanderthalensis*, *sapiens* and *sapiens sapiens*. In addition, Cela Conde has made a relevant empirical review on the results of his own research. It has been referred to the neural correlates of aesthetic or ethical activity of human beings.

Javier Monserrat's contribution to this session of the seminar will rethink our idea of the brain as a determinant factor for understanding the origin and nature of reason. Monserrat considers that the acceptable sentence «man is his brain» or «the mind is a functional state of the brain» incite science to a thorough discussion. It would lead to assume a commitment for a mechano-classic option, as Edelman does, or to take an alternative way towards the today so called hypothesis Von Neumann-Stapp. It is legitimate to keep within the limits that each researcher considers to explain reality. But it is an epistemological requirement of science to produce knowledge about the nature of the «physical support» from which the brain activity and the brain functions emerge.

I. FRANCISCO MORA'S PAPER AND PRESENTATION: THE EVOLUTION OF THE HUMAN BRAIN: A BRIEF RETROSPECT

Around four million years ago the genus *Australopithecus* appeared, to be followed, two million years later, by the *Homo* genus and the hint of a culture that would later develop into what we are today. The study of the brain is a multidisciplinary subject and it is precisely this convergence of many disciplines that allows us to reference humanistic input as well as scientific input.

Understanding the brain implies accepting that, as we are working with fossil records, we need to create certain general models for its evolution.

It is now possible to trace some of these models back about 425 million years. The first recorded jawless fish date back to this time, and it is both interesting and curious to see how the general model for the construction of the nervous system already appears in these fossils, i.e. the spinal cord and the brain stem, etc.

Our origins are diverse, and the branches that have grown from this diversity are numerous. There are even models which, in spite of having remained constant, have diverged in such a way as to give rise to truly amazing cases such as the dolphin. Although its encephalization quotient is very similar to that of human beings, the dolphin has a brain that is so different from ours that we would need a long time to discuss the difference between how dolphins and humans process information. Let me reiterate that it has a very similar encephalization quotient.

Going back to the general models, comparative studies have been made using live animals. It is precisely these studies that best allow us an insight into the brain function of chimpanzees, for example, which are separated from humans in terms of the common trunk by seven million years. We must also take into account the theoretical inferences that can be made based from current theses, and the technology that allows us to infer some brain functions. Of course we do this through comparative studies, but we also look at it from other viewpoints.

The basics of the evolutionary process of the human brain can be found in the studies of neuro-palaeontologists Phillip Tobias and Ralph Holloway. Thanks to their studies, and based on their findings, we know that after *Australopithecus africanus*, with 460 cm^3 or gr. of brain there was a jump to *Homo Habilis*, with a brain of between 700 and 750 gr. We then continue past *Homo erectus*, and the rest of the species, until we arrive at the 1,400 gr. brain of *Homo sapiens sapiens*.

It should be remembered that when talking about the brain and its weight we must take two components into account. One is the allometric component (i.e. the relationship between the weight of the brain and the weight of the body where greater body weight corresponds to greater brain weight), and the other is the absolute increase in the brain weight. To understand this we need to discuss the concept proposed by Jerison in 1973 which refers precisely to the amount of brain not related to the body, in other words, to the absolute brain increase or encephalization quotient that in humans is seven times bigger. This means that human beings have a brain seven times heavier than that which corresponds to their actual bodyweight.

Thanks to a relatively recent investigation we can follow the progress of brain weight. It can be summarised in the following way: between *Australopithecus Afarensis* and *Africanus* there is a gap of approximately half a million years, during which there is an increase of at least 450 cm^2. The body of *Africanus* was heavier than that of *Afarensis*, and this resulted in an increase in brain size, in the same way it would have happened with all the other organs of the body (the liver and kidneys, etc). In other words, a relative increase in brain size occurred.

Between *Africanus* and *Habilis* the genus changes from *Australopithecus* to *Homo* and there is a period of 700,000 years during which changes are produced in the brain which are both allometric (related to bodyweight) and non-allometric (absolute increases). During this period the intrinsic weight of the brain increases from 450 to 750 cm^3. In the change from *Habilis* to *Erectus* the change is fundamentally allometric, increasing from 750 to 900 cm^3. In the change from *Erectus* to *Sapiens*, in this case the Neanderthal, Holloway estimates that the brains reaches some 1,400 cm^3 although the average is actually around 1,350 cm^3 with a non-allometric increase occurring (in other words, without the bodyweight changing, the weight of the brain increases considerably). Finally, it is estimated that barely 15,000 years ago a small change occurred in the brain consistent with a decrease in weight related to a decrease in bodyweight.

All the above has a very long and interesting history. In the last two million years, not only has cranial capacity increased, but the encephalization quotient has also increased spectacularly from two in *Homo habilis* (two or two and a half million years ago) to approximately seven, as previously mentioned, which Man has today. The most interesting part of all this is that in addition to the absolute increase in the weight of the brain, it has also undergone a reorganisation. During the last 2-4 million years there have been reductions in the brain (some areas of it have become smaller) and it has expanded in other areas. Moreover, the reorganisation has been asynchronous (out of step time-wise) in a particular area of the brain which is enormously important. Of course there has also been an asymmetric reorganisation: differentiation between the right and left brains took place. All this has led to extensive debate on when the reorganisation actually began, and whether it was between *Afarensis* and *Africanus* or later, after *Africanus*, before the increase in weight. While some believe that the reorganisation occurred when the weight of the brain increased, others believe it was before the increase.

Korbinian Brodmann was a neuro-pathologist who, around 1901, sub-divided the cerebral cortex into 52 different areas according to their cytoarchitecture. This distribution is still incredibly useful and is used in surgery even today. Furthermore, we can use it to talk about the reorganisation that took place in the brain by referring precisely to the cytoarchitecture of the brain itself. In the time between *Afarensis* and *Africanus*, three to four million years ago, changes occurred in areas 17, 18, 19, 7, 39 and 40. At the same time the important differentiation between the right and left brains, as regards size, also began. In scientific jargon these are known as petalias, from *petallos,* which means leaf or protrusion in Greek.

During this period, some three of four million years ago, there was a minimal increase in the weight of the brain and some variation in different areas. Area 17 reduced in size enormously in Man, and areas 18, 19 and 7 (the posterior parietal area) expanded proportionally. This had enormous functional implications. It is also important to point out the angular gyrus and the supramarginal gyrus (which correspond to areas 39 and 40) and the extension of area 22 in the posterior parietal part (Wernicke area) which is used to understand language.

The reduction in area 17, the primary visual cortex, most probably occurred more than 30 or 40 million years ago as it can be seen in the Rhesus monkey. As a result, this reduction exists in the brains of anthropoids from the chimpanzee to the orangutan. Area 17 is the primary visual area which receives the information transferred from the retina via the lateral geniculate nucleus of the thalamus.

Let us now move on to the second reorganisation of the brain which takes place between *Africanus* and the *Homo* genus, more specifically in the *Habilis* species. As you can see, some changes occurred in *Habilis* which were inferred from specimen KMN-ER 1470. The major changes took place in the frontal or prefrontal inferior cortex, which correspond to Brodmann areas 44, 45, and 47. All this has implications of great interest. In the field of humanities, it is quite rightly said that the construction of language ended some 100,000 years ago and that «*a new collection of sounds, those of articulated language, could be heard in Africa two million years ago*». With this came a new level of organisation in the evolution of life on earth, because language is a vehicle for symbols, and it is now a wonderfully human ability. Using language as a tool we then, to a certain extent, built the world. Different languages even built the world in different ways. Language is a symbolic vehicle that creates, and it is this dimension that can be refuted or debated.

The third stage of reorganisation first takes place in the asymmetry, the petalias. The right frontal lobe is larger and protrudes further than the left, while the left occipital lobe does the same in relation to the right. This has many significant implications which must be studied to enable further investigation of the origins of the brain. We must find brain functions by using comparisons with living animals, as what is left in the fossils we find could see us debating eternally.

There are studies today which, using very complicated algorithms, have extrapolated the brain from the chimpanzee (Bonobo) to Man in order to carry out a comparative study of evolution. What is extraordinary is that the prefrontal cortex has expanded enormously, especially the orbital prefrontal cortex. The functions of the cerebral cortex do not have exact locations, rather they are systems distributed throughout the whole of the cerebral cortex, even if there are nodes belonging to these systems in specific areas. One of these such areas could well be the prefrontal cortex itself.

Focussing on the orbital frontal cortex, and on the orbital part in particular (and looking at it from a ventral viewpoint), we have Brodmann areas 10, 11, 13 y 17. Area 10 is the most frontal or forward area and is, proportionally, six times larger in humans than in the Bonobo. Why is this important? Primarily because it enables us to understand what comprises the essence of the human being, in other words, making conscious decisions, establishing concepts, making moral judgements, and planning for the future. The nodes and circuits in this area of the brain are fundamental in this behaviour for which there is undoubtedly no precedent on the evolutionary scale.

The functions linked to Brodmann area 13 are basically related to control codes and functions of the brain systems of reward and pleasure. They are codes through which this part of the brain contributes to the inhibition of the emotional limbic system, suppressing tendencies, and suppressing the animal instincts we have, therefore, forming the basis of sociability. Being social and respectful basically implies the ability to stop certain impulses that one clearly may have. This area is also larger in humans (three times) than in the Bonobo. By using such sophisticated techniques as these, we can extrapolate functional aspects from the comparative studies made between current living beings and what our predecessors supposedly were.

And there is more. In hominoids, i.e. anthropoids and humans, new neurons have appeared in the brain. This refers to the fact that, not only has the human brain increased in weight by a kilo, but there has also been a qualitative change in it. These new neurons have a very special morphology due to the bipolarity of their two dendrites, in both their upper and lower parts. What is really extraordinary is that they appear in the evolutionary scale from the anthropoids onwards and are more abundant in human beings precisely in the areas and nodes that are related to the circuits which produce specifically human behaviour, such as the anterior cingulate cortex and the orbitofrontal cortex. In other words, they are those related to the inhibitions we spoke of, and those associated with decision-making, i.e. key areas of the humanisation of human beings. They are, therefore, also interesting evolutionary aspects.

What selective pressure made the 400 gr brain weight of an animal increase to almost one and a half kilos and caused such a drastic unprecedented internal reorganisation over a period spanning two million years?

There are theories, such as those of Krantz and Fialkowski, which try to provide some kind of explanation for at least the beginning of these processes. Krantz upholds that *Australopithecus* (and *Africanus* in particular) adopted what is known as «persistence hunting», in other words, choosing an animal from a large group and focussing their attention on it, chasing it until they bring it down. This requires a great deal of continuous attention and, very importantly, the ability that those with an erect posture already possessed: the ability to run. According to Krantz, the organism in its erect state is obviously in a better position to focus its attention while it is running. Logically, it is better adapted to running and walking than, for example, a chimpanzee. In any case, it is presumed that these first individuals ventured out onto the arid plains in pursuit of their prey. This possibly led to a change as dramatic as that of body temperature control. Fialkowski assumes that many specimens must have died as persistence hunting requires chasing the animal for two or three days and hours of uninterrupted running which would lead to an increase in body and brain temperature resulting in heat shock and death. Based on a mathematical theory applied to computers, Von Newman suggested a system can partially function even if its units are not functioning correctly, as long as the units are sufficiently or well interconnected.

Based on this assumption, Fialkowski proposed that individuals that by chance had larger brains would have had more units (neurons) that would, therefore, be better interconnected, resulting in a malfunctioning brain, but one which was more resistant to shock. The consequence of this is selective pressure in favour of larger brains in descendents. There is no doubt that over the last 2-3 million years an infinite number of large and small convergent processes have occurred which have led Man down a line of constant progression with regards to the increase in brain size and reorganisation.

II. CAMILO JOSÉ CELA CONDE'S PAPER ANS PRESENTATION: THE AMERGENCE OF REASON IN THE ORIGINS OF MANKING

In his Notebook C, Charles Darwin recorded the following thoughts on Man:

> «He is Mammalian / he is not a deity / he possesses some of the same general instincts, & moral feelings as animals but Man has reasoning powers in excess. Instead of definite instinct – this is a replacement in mental machinery – so analogous to what we see in bodily, that… it does not stagger me» (Darwin, 1836-1844).

According to Darwin's belief, when we talk about a human being we are talking about just another animal, albeit a thoroughly special animal, with heightened abilities of analysis and rationalisation. Something happened to the mental machinery during the process of evolution from the common ancestors of apes and humans to our own species. As a species we obtained something important which, in keeping with Darwin's theory, illustrates the obvious fact that our mind is different from that of other primates.

But what is it?

In Darwin's time this basic question could not be answered in any other way than by using intuition based on common sense, an intuition which the author of *The Origin of Species* recorded in his notebook as: very strong powers of reasoning. Today we have empirical evidence that this intuition was correct, even though it has taken time to collect the proof. Twenty years ago, Richard Lewontin, one of the great theorists of Darwinist thought, made the following compelling statement:

> «If it were our purpose […] to say what is actually known about the evolution of human cognition, we could stop at the end of this sentence» (Lewontin, 1990).

Two decades later, what more do we know?

The systematic characterisation of *Homo Sapiens* is more complete than 20 years ago, and a great deal more so than 150 years ago when Darwin began to consider the question. Thanks to neuroimaging techniques, we are now able to begin to comment on the cerebral correlates of the mind. Comparative behavioural studies of other primates add further evidence of types of behaviour. Nevertheless, when

discussing evolution, palaeontology is the key: palaeontological data has to be used as a starting point to explain any phylogeny, especially, the phylogeny of the mind.

Let us look at the new evidence. We will begin with the comparison with apes. In 2007, Tomasello's research team published an article (Herrmann, Call, Hernandez-Lloreda, Hare, & Tomasello, 2007) on the ontogeny of intelligence. The article compared the behaviour of chimpanzees and orangutans not with the behaviour of humans, but with the behaviour of very young humans of about two and a half years old, with the aim of observing the differences that exist before the completion of the exterogestation process (the development of the mental brain), in other words, close to the starting point for human socialisation. At least two years are needed for the brain to mature sufficiently to produce the articulation of language.

The study made by Herrmann and his collaborators analyses different cognitive abilities measured with a series of experimental tests on young children, chimpanzees and orangutans. The cognitive abilities that are analysed are spatial awareness, quantification (the ability to have a numerical idea of the world), and causality (the ability to relate cause and effect). The work of Tomasello's team shows that, at the age of two and a half, humans have the same abilities as apes in many areas. There are no detectable differences. However, if we look at the aspects related to communication, even at two and a half years of age a child already has abilities which are far superior to those of chimpanzees and orangutans. Here we are referring to achievements where the main difference is regarding the attribution of a mind theory to the individuals we are interacting with. In other words, the ability to understand that other people, or animals (depending on the case in point), think.

If this mental trait is compared with others such as the ability to understand consequences with regards to cause and effect (which is similar in small children and apes), the difference is dramatic. It is also surprising, taking into account that chimpanzees demonstrate a very rich social life. The development of the concept of Machiavellian intelligence with regards to ethology (Byrne & Whiten, 1988) is based on the ability of chimpanzees to lie, reach agreements and establish wide-ranging social relationships. Nevertheless, this rich social life cannot be compared to that of humans who are two and a half years old. The cognitive ability of the latter is far superior in the area of communication.

Systematics has also changed significantly over the past 20 years. As an example of what is now known today, John Carroll (2003) provides a list of derived traits in modern humans, in other words, the apomorphies of our species (technically speaking, an apomorphy is a trait that is exclusive to a specific lineage, that does not appear in the sister group). Carroll uses chimpanzees as the sister group as they are our most closely related living primates. The human derived traits, proposed by Carroll, which chimpanzees do not share, are mostly anatomical, and many of them are related to a single functional trait: bipedalism. Professor Mora was absolutely right when, during his presentation, he highlighted

the fact that bipedal locomotion is the basic trait that has separated us from chimpanzees for seven million years. If we have a spinal column in the shape of an «S», a short, wide pelvis and the spine inserted low down on the cranium, (quite strange traits from a mechanical point of view), it is due to the fact that the bipedal trait is peculiar to humans and has forced numerous anatomical changes.

However, there are two more functional traits that John Carroll (2003) considers: firstly, the ability to create complex tools, and secondly, language. Language is the ability to communicate with others using communication based on symbolism, one of the keys to humanity, in the sense that we define Mankind from a systematic point of view.

The process by which these apomorphies have been acquired has been gradual over different genera and species in the evolution of the human lineage. Although bipedalism appeared as an essential trait over seven million years ago, the first tools are found in the fossil record from only 2.5 million years ago. These tools are the evidence of the separation, in cladogenetic terms, of two genera in human lineage. One genus, *Paranthropus*, adapted to the savannah by developing anatomical structures which allowed the individuals of this taxon to ingest tough vegetable matter. The other, *Homo* genus, developed a greater cranial capacity and the tools John Carroll speaks of.

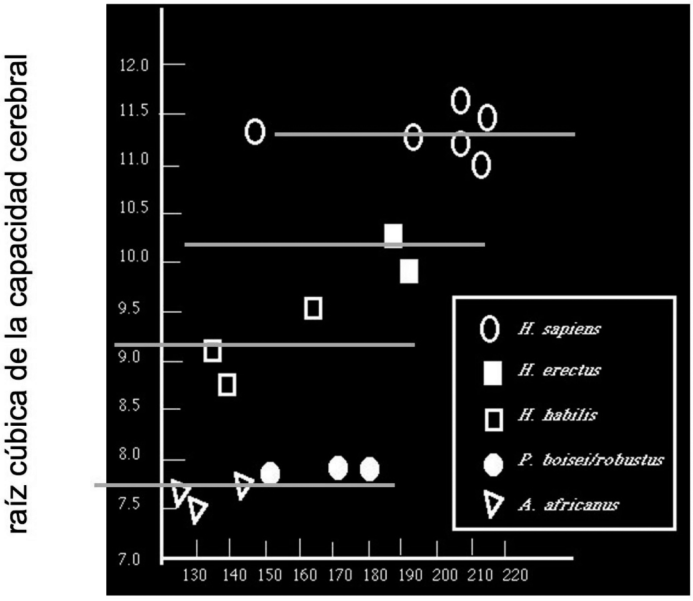
As regards language – which is even more difficult to identify in terms of evolution – we may think that, in its final stage, it is related to an evolutionary event that took place around half a million years ago; the separation of two species, the Neanderthals and modern-looking humans. The most likely null hypothesis regarding the development of language is that it is only present in *Homo sapiens*.

All functional traits, bipedalism, tools and language, are related to brain development. Profound changes must take place in the brain to create bipeds, but also to make complex tools and to be able to speak using double articulation in language.

There have been three crucial moments in brain development if we look at the indicator which allows us to measure the relative size of the brain, the encephalization quotient (Jerison, 1975) (figure 1).

Starting from the basal line (where the encephalization quotient is practically the same for both chimpanzees and the first Australopithecus), *Homo habilis* (provided that we include Leakey's KNMR 1470, 1973, in this taxon) shows an extra-allometric increase which is greater than that corresponding to the increase in body size. Two later increases appear in *Homo erectus* and both Neanderthals and anatomically-modern humans.

However, we are discussing the origins of the mind, not the brain, so we must ask ourselves if we have really made any advances in regards to the identification of the evolutionary process of mental machinery. We must proceed with caution when expressing our ideas on the evolution of the mind, and clarify if we are talking about hypotheses (just guessing) or empirical evidence. Even



GROVES, C. P. (1989): *A Theory of Human and Primate Evolution*, Oxford: Clarendon Press (modified).

FIGURE 1: *The encephalization process Cubic root of cerebral capacity Glabella – opisthocranium measurement.*

in specialist literature there is often confusion along these lines: something that is only intuition or a suggestion can then be given as proven almost in the same sentence.

As an example of the extent of this problem, let us look at some initial axioms. The first holds that the mind is a functional state of the brain. This is actually a proposal put forward by computational functionalists such as Hilary Putnam and Noam Chomsky, but it is accepted today even by the most staunch dualists.

Let us also assume, as an axiomatically accepted principle, that cognitive activity stems from the activation of neural networks. If we do not believe this to be true, then we can advance little in any plausible explanation of the functioning of the mind.

Thirdly, let us believe that neuroimaging techniques detect neural network activity, leaving aside any doubts which exist with regards to it.

However, even if we accept these prior conditions, certain problems still appear, especially with regards to the relationship that exists between the mind

and the brain. When we say that the mind is a functional state of the brain, how far can we reduce it down?

In his book *Rules and Representations*, Chomsky (1980) explains the idea of computational functionalism which, for him, is an environment which allows us to still uphold a certain dualism. Not dualism in the sense expressed by Descartes, but as a formalisation of the fact that perception is not the same as knowledge. Let us take visual perception as an example. Thanks to this visual perception, after specific cerebral processes, an image of the world appears. One thing is optic nerve signals entering area 6 of the occipital part of the brain, and quite another is the picture of the world the mind ends up creating – a mental ability our «self» possesses. The brain comes between the outside world and knowledge (few people doubt this in today's world), but it would be a good idea to explain exactly how it does it. For Chomsky, the mind cannot be reduced simply to the brain.

In establishing the relationship between the mind and the brain, we are suggesting that when I contemplate an outside element, such as some clouds in the sky, I am linking three things (an external object, cerebral organs and knowledge) which do not belong to the same order of explanation. For Chomsky, the physical world and the brain itself can be explained scientifically. However, we can only access human feelings and mental knowledge in terms of common sense (Cela Conde & Marty, 1998).

In its most advanced state, knowledge is the result of a functional state of the brain, but it includes a series of components which we are unable to explain today. These components are also personal. If there are 7,500 million people, that is 7.5 billion individuals capable of knowing in their own particular way. In other words, an object and a cerebral organ lead to a kind of knowledge that can be essentially different in each and every person.

The cerebral correlates of mental machinery can now be shown thanks to neuroimaging techniques. These techniques have clarified different aspects of the contents of the mind which, according to the apomorphies of John Carroll, are essentially language and (thanks to this language) the development of symbolic elements. Nevertheless, it is important to add two further mental aspects (not included in John Carroll's list): moral judgement and aesthetic preference. That is, the ability to make moral statements, evaluating the behaviour of those around us, and to profess aesthetic opinions regarding the objects we see. I will refer to these when talking about the advances made thanks to cerebral imaging.

Moral judgement

Philosophers have spent at least sixty or seventy years considering the content of moral judgement and making subtle distinctions between its different applications in different situations.

A well-known example dating back to the time of the development of analytical moral philosophy indicates the existence of paradoxical aspects in the functioning of the human mind.

Let us imagine a tram travelling without brakes on a tramline. Five workers are repairing the line and have not realised that the tram is approaching out of control. They will be run over and killed by the vehicle. I, however, can avoid this by activating a lever that will divert the tram onto a secondary line where there is a different man at work. If the person pulls the lever, they will save the lives of five people and kill another instead. The question that moral philosophers have been asking participants in this experiment for the last sixty years is if they would pull the lever.

In statistical terms, between 70% and 80% of those questioned answered yes, and when asked why, they were puzzled. It seems obvious: the choice is between the lives of five people and that of one, it is simple.

But is it is that simple?

Let us change the perspective a little: it is the same situation, but now I do not have a lever in my hand. I am standing on a bridge over the tramlines and next to me there is a horrible, disgusting, fat, dirty, foreign person (add all the pejorative adjectives you can think of) who smells and has just sworn at me. Absolutely horrible. What I can do to save the lives of the five workers is to push this horrible person onto the line. The tram would stop when it hit the fallen person.

The question is the same. Would you push the person?

What difference is there between one case and the other? There seems to be none. In both cases we are talking about killing one person to save five others. However, the percentage of those questioned who replied yes in the second scenario falls to less than 10%.

Joshua Greene (a psychologist from Harvard University) and his collaborators have explained this paradox by measuring the brain activity of people confronted with some kind of dilemma (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). In their research, Greene and his collaborators made a distinction between impersonal dilemmas (those which simply involve an analysis: it is worse to kill five workers than just one) and those which have personal implications (to save the workers I have to push a person thereby killing them). There is a significant difference. It is not the same to press a button to launch a missile that will kill 300 people in an Iraqi village as to go to the village itself and cut their throats with a knife. It is neither the same in terms of moral decision-making nor in terms of brain activity.

In personal moral judgements, when the subject feels they are directly implicated in the problem, the middle frontal *gyrus*, the posterior cingulate *gyrus* and the angular *gyrus* are activated, whilst, when the decision is made of whether to pull the lever or not, it is the dorsolateral prefrontal cortex and the parietal lobe that are activated (Greene *et al.,* 2001). In other words, we are not using the same areas of the brain when we are faced with one moral dilemma or another.

If we apply this discovery to moral philosophy throughout history, it is fair to conclude that Kant and the Utilitarianists were not referring to the same type of thought. Kant's assertion regarding the true worth of a person is not a real

alternative to Utilitarian thought which values the greatest good for the greatest number of people.

Aesthetic judgement

As regards aesthetic opinion, the field we are looking at is different. To put it into context, I would say that what Professor Mora proposed in his presentation is true: something happened between 150,000 / 100,000 and 30,000 / 25,000 years ago. This something led to the appearance of colourful cave-paintings in the caves of the modern-looking humans. This is something new, something unseen in the previous seven million years of human evolution. Something had to happen for modern-looking humans to suddenly be compelled to carry out polychrome representations of the reality surrounding them, leading to aesthetic works as complete as those in Lascaux and Altemira. A fundamental question springs immediately to mind: is it reasonable to think that it was certain cerebral changes that gave rise to a human being that showed an interest in such interpretations of the world?

In 2004, while trying to understand the relationship between aesthetic judgement and the brain, the research team I belong to published a first article highlighting the activation of neural networks in relation to aesthetic perception (C. J. Cela-Conde *et al.,* 2004).

Our study based aesthetic judgement on the dichotomy «beautiful-not beautiful», and it was the subjects of the experiment themselves who decided in each case whether an object presented to them was beautiful or not.

In our work we used an extremely wide range of stimuli as our conviction (which I expect is shared by everyone) was that beauty is something very personal. However, the variables were reduced as much as possible: the only participants to take part in the study were women studying at post-graduate level in the Universidad Complutense. This was to avoid any possible scattering of the results that may have occurred if we had included other variables such as age, sex and education.

The recordings of brain activity were made using magnetoencephalography (MEG), a technique which measures the magnetic activity generated by the postsynaptic activity of neurons. The decision was made to use magnetoencephalography rather than the more usual technique of functional magnetic resonance imaging (fMRI), as the MEG technique gives a very high temporal resolution. Whereas fMRI gives an average reading of what occurs in the brain over two seconds, MEG measures the state of the brain every millisecond. We do not possess the computer power to appreciate quite such detail, but we can look at hundredths of a second. Furthermore, the spatial resolution of MEG is acceptable if used in combination with a magnetic resonance of the brain of each subject.

The only difference our study revealed showed that beautiful stimuli activate the dorsolateral prefrontal cortex of the left hemisphere (figure 2). This area was

also activated by the not-beautiful stimuli, showing that the dorsolateral prefrontal cortex comes into play in all judgements. The crucial difference, however, was to what degree it was activated (figure 3).

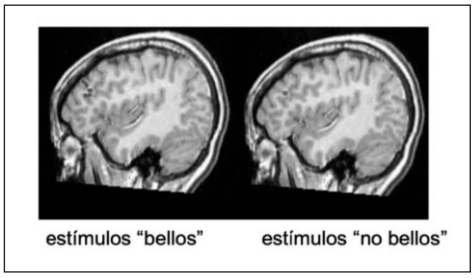


FIGURE 2: *Activation of the dorsolateral prefrontal cortex of the left hemisphere «beautiful» stimuli «not-beautiful» stimuli).*

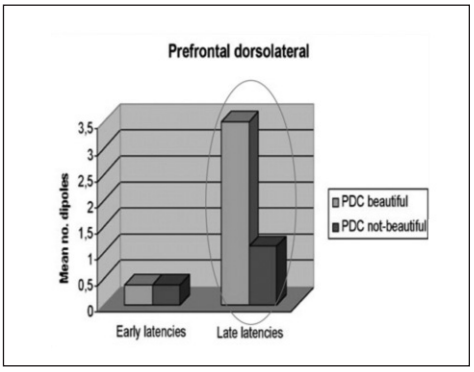


FIGURE 3

The mental process of identifying the beauty of an object lasts between 500 and 900 milliseconds. If any of you are teachers and you have to battle with children when you take them to a museum, don't worry if your pupils don't seem to be interested. If a child is not paying attention to the paintings, it is because the perception of possible beauty has taken place in half a second. In early latencies there is no activation of the prefrontal cortex (figure 3), which is logical as the perception signal is located in the occipital. However, as I have said, in latencies of over 500 milliseconds there was a significant difference between the cases where the subject thought a stimulus to be beautiful and where they thought it was not beautiful.

In recent years, there has been an abundance of studies on the relationship between aesthetics and the brain. Among the most recent works is one of our own in which we introduce a new variable: sex (C. J. Cela-Conde *et al.*, 2009).

How do men and women perceive beauty? In both sexes the activation is clearly parietal but in different hemispheres. Women use both brain hemispheres to perceive beauty whilst men only use one, the right hemisphere (figure 4).

What is most interesting about this result is that it indicates there must be a cognitive sense underlying these differences. The use of the brain is not free; brain tissue requires many metabolic resources and we must not think that unnecessary aspects appear which have not been determined by natural selection. We now need to explain these differences from an evolutionary point of view.

The best interpretation available is that for 2.5 million years the groups of hunter gatherers that were the descendants of humans probably divided the work: the women were gatherers and the men hunters.

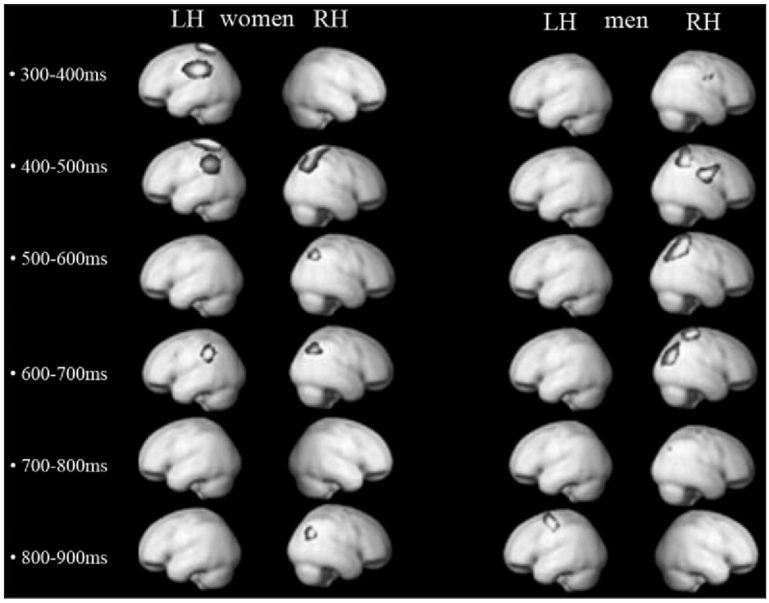


FIGURE 4

It can be expected, therefore, that the elements in the neural networks related to perception and spatial awareness developed more in men (a clear spatial perspective is required for hunting), whilst for women semantics were crucial: they had to distinguish between the different roots, leaves and fruits gathered according to whether they were edible or not.

This resulted in selective pressure towards semantic development in women and spatial development in men. Towards the preferential use of the right hemisphere in men and additional semantics in women.

FOSSIL EVIDENCE

Although I referred to them as crucial at the beginning, I am not going to talk in detail about the advances made in studies of the fossil record over the last two decades as Professor Mora has already referred to them. I will only point out that we have fossil evidence of welfare and moral behaviour. Such evidence is shown in long-known Neanderthal specimens such as the «Old Man» of La Chapelle, who reached such an advanced age as to lose all his teeth. How did he survive if he was suffering from such general organic deterioration? Only with the help of the rest of his group.

Nowadays we have a much older example of an edentulous (toothless) skull: specimen 3444 from Dmanisi, Georgia (Lordkipanidze *et al.,* 2005), classified as *Homo georgicus*, the beings who first left Africa about 1,800,000 years ago.

We have, therefore, almost two million years of evolutionary history behind us showing our need to maintain relationships based on affection and appreciation, and where we invest our own resources (which is the technical definition of biological altruism), in favour of those individuals who are close to us.

The archaeological evidence supports both the moral and aesthetic questions, starting with tombs.

The only hominins to bury their dead were the Neanderthals and modern humans. However, if we compare Neanderthal tombs such as the Kebara tomb, and Cro-Magnon tombs like that of Arene Candide in Italy, a crucial difference is revealed: no Neanderthal tombs show any signs of ritual, whilst those of the modern-looking humans include coloured pigments and decorative items. The tombs of modern humans contain proof of symbolic thought.

Symbolism

When does behaviour showing symbolism appear? The European artistic revolution (the cave paintings I referred to earlier) which took place almost thirty thousand years ago, presents us with a paradox: if symbolism appears at that time and the human species around 100-120,000 years ago, how should we view this time difference? Do we presume an *ad hoc* mutation of the brain at the time of the emergence of cave painting, as has happened on other occasions?

It seems that there is a different problem. Modern-looking humans arrived in Europe thirty million years ago. If we only look at the archaeological records corresponding to this era, we will not find any evidence of previous mental activity. However, when a search was made in Africa, much older examples of symbolism appeared.

The best example is Blombos Cave at the mouth of the river Klasies in South Africa. Dating back seventy thousand years, the cave has revealed signs of a more advanced technology than the Mousterian technology of the Neanderthals. In Blombos Cave there are also perforated shells which formed part of necklaces. Not having any direct use, these necklaces are considered decorative (Henshilwood, d'Errico, Vanhaeren, van Niekerk, & Jacobs, 2004).

Pieces of ochre that decorative pigment would have been extracted from have been found in Blombos Cave, but there are no paintings on the walls of the cave. What did they use the colours for? Probably in the same way as we use colour: humans in those days would use these pigments to decorate their bodies, probably as a sign of hierarchy.

What changes did the brain of modern-looking humans undergo in comparison with Neanderthals? Unfortunately, almost all the inferences available (mentioned by Professor Mora) are interpretations of only a very few fossils that are also difficult to analyse.

Going back to the fossil record I was talking about, the most plausible hypothesis is that after *Australopithecus afarensis* (at the time the evolutionary lines divided

to form the two separate lines of the *Homo* genus and the *Paranthropus* genus), a process begins whereby in addition to the increase in cranial capacity, the organisation of the cortex was refined. From the descendants of the first of the Habilis genus, *Homo erectus*, onwards, the process was different in the Neanderthal line and in the modern-looking human line. This is portrayed in the studies of Emiliano Bruner (Bruner, 2004; Bruner, Manzi, & Arsuaga, 2003).

The 800 cm^3 capacity of *Homo erectus* changed to around 1,600 cm^3 in Neanderthals and 1,350 cm^3 in modern humans, each following different paths which implied basic differences between Neanderthals and modern-looking humans.

In a way, the brain of a Neanderthal was the brain of *Homo erectus* times two, but which maintained the plesiomorphic patterns, keeping the volumetric cerebral characteristics of *H. erectus*. However, in modern-looking humans the occipital zone became reduced in size and the frontal and parietal zones developed further.

These frontal and parietal zones are exactly the areas that are activated in our studies on the brain's response to beauty. Unfortunately, current techniques do not allow us to check which areas would be activated in Neanderthals in similar circumstances.

The evidence, therefore, is only partial. We have advanced a great deal over the last two decades as regards understanding the phylogenesis of the human mind, but there is still a very long road ahead.

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III. DEBATE WITH FRANCISCO MORA AND CAMILO JOSÉ CELA CONDE

The moderation of this debate was in charge of Javier Monserrat.

JAVIER MONSERRAT: ***Introduction to the debate with a summary of previous sessions*.**

JAVIER MONSERRAT: I would like to talk about two things. In the first session of the seminar (that was held a few months ago), taking into account what Professor Roberto Poli from Trento University said, a question was put forward regarding the understanding of what life is and how reason connects with life and is a result of life. The angle chosen by Professor Poli was to try and explain both life and reason in terms of systems theory. This was his contribution.

I, personally, really enjoyed the contribution made by Professor Poli (which was later opened to discussion) as I have been studying philosophy for many years and am a member of the Zubiri Foundation and, as such, I have connected many of my ideas with Zubirian thought. I have always been interested in the idea that what the human mind really is and what characterises it is the fact that it has evolved to acquire a psychic ability that has enabled mankind to form the idea that the world is, deep down, something built like a structure, like a system. From my point of view, the presentation made by Professor Poli was closely connected to this idea. We could say, therefore, that one of the conclusions which can be drawn from this seminar is the following: if we ask ourselves what the origin of reason might be and what was involved in the origin of reason, an idea which is interesting to highlight is the following: the fact that Man has produced reason because humankind, having reached a certain maturity of neurological evolution, has had the ability to realise that the world is a structure, a system. Consequently, humankind has been able to follow this thread to analyse the reality of what these structures were.

Another idea which, although different, complements that previously mentioned, and which arose in the second seminar session, is that contributed by Professor Harald Walach from the University of Northampton and also by Professor Gregor Nickel, and which stems from the field of formal sciences, in particular that of mathematics. But

perhaps the most interesting idea of the second session was that proposed by Professor Walach regarding his analysis of *entanglement*, which comes from quantum mechanics and that he perceives as an aspect of Man's experience, which is entangled with reality, caught up in it. In his presentation, Walach did not want to establish a relationship with what are today the theories of the quantum origin of the mind (Penrose). He disassociated himself from those theories, but highlighted the fact that human experience is an experience of entanglement with reality. The underlying matter is, perhaps, that this experience of entanglement or link with reality or, in other words, this holistic experience that allows Man to exist in the world via his senses, has also probably influenced the origin of reason.

Therefore, if we had to identify two basic ideas stemming from this seminar so far, we could say that in some way the origin of reason results from Man experiencing reality as a structure and that he began to reason when he started to analyse the world in terms of structures and systems. But it is not just that. Probably what characterises the human use of reason also depends on a second aspect, that is the fact that Man has a holistic experience of reality which also influences his way of reasoning and the formation of his mind. These are two ideas which have been brought to the table and I think that, in order to develop them and incorporate them into what we call the «fourth level» (that of causal theory), they have to be linked to the world of neurology and with the experience we have of how reason really appeared and emerged in Humankind, in primitive peoples, in *Homo Erectus*, and in fact in all the processes so carefully described to us by Camilo José Cela Conde and Francisco Mora.

Regarding the first matter, I believe that deep down it is about trying to find the neural bases for the functioning of the human mind. Interesting elements which show this connection arose in the presentations of both Mora and Cela Conde: language, symbolism, etc. Many things have been mentioned, including socialisation. Regarding the second point which was discussed in the second seminar session on holistic experience, Professor Mora explained how the emotions a person has regarding what is real, which are very much linked to religiousness, are an important element to be considered when investigating the origin of reason and the nature of Mankind. It could be said that the religious or mystical experiences that Man occasionally experiences were also determining factors in the formation of human reasoning. We are speaking, in fact, of a whole range of processes.

Personally, I think that when we try to explain from a neurological point of view how Man has reached this way of specific thinking which makes him rational, there is a connection which has not been much worked on – many connections have been made, such as what Cela called neurological correlates, which have been studied in depth, hence the abundance of references –, but I would say that altogether the real transition from the most primitive psychic experiences of animals to the incredibly complex reasoning of humans is a process which has not been properly studied.

There are some transition elements which seem very interesting to me, such as memory, for example. As Edelman says, our brain records experiences in real time and is able to link past experiences to the present to later mix it all up. This leads me to think that the memory is probably the germinal element of all the neurological process which leads to the complexity of the mind. A subject that I believe should be studied in more depth is how the idea of reality appears (if it does, in fact, appear and, if so, based on what biological processes) as a structure, seeing the world as a system. How does it happen? Personally, I think that it should be interpreted in relation to what Professor Mora said when he referred to the process of abstraction, imagination and representation of reality and structure. The representation of reality and structure is probably the result of this evolution

produced by abstraction and imagination, which are processes that probably appear in a germinal form in the animal world.

This is what we have dealt with so far in the seminar, and in relation to it I would like to ask a question to Professors Cela Conde and Francisco Mora, who have so kindly participated in the seminar itself: How do you see (if you do see it, because maybe you do not and that would also be interesting to know) the role that those two factors have played (if they have played a role) in the emergence of reason? On the one hand, the process of analysing things as a system, something which has been thoroughly developed and studied and has led to all the sciences that we know today, such as the physical sciences, which are essentially an analysis of the world as a system. On the other hand, the mystical element, which has not been so exhaustively studied and for which there are no physical bases. This would be the most holistic and most mystic level of experience that Man has of things, which produce those deep emotions when faced with the cosmos and which also seem to have played a role in the life of primitive Man. Those are, therefore, the two subjects dealt with so far in the seminar: firstly, the topic of the analysis of reality and of reason in terms of systems theory or in terms of the representation of reality as a structure and, secondly, the experience mentioned by Professor Walach, that is the more holistic, more integrated, experience of the cosmos, which probably engulfs Man and produces his mental activity.

With this we can now open the debate which is the final part of this fourth session of the seminar. Professors Cela Conde and Mora will now speak and the discussion will then be opened up to the audience so they may make their contributions.

Francisco Mora: ***Does reality exist? One reality or multiple realities?***

Francisco Mora: Why don't we challenge the audience? «Reality as such does not exist…» Now we've given cause for debate…

A man from the audience: We have heard that if there are 7,500 million people, there are 7,500 million realities or ways of viewing reality, if a single reality exists.

Francisco Mora: The most important thing is to find a common parameter regarding what we understand as reality. I believe what is clear is that we have electromagnetic waves, in other words, light. Then there are pressure waves, which is what we understand as sounds. We also have molecules which allow us to create taste, smell, and finally all the mechanical deformation of the skin along with its deterioration, which is pain, vibration, touch, itching. The matter of energy can be discussed, albeit little, but what we should debate is how living beings have evolved over 700 million years obeying only one law: the supreme law, which is the law of survival. There is no other ladies and gentlemen: there is no other, not in this forum or in any other. All the formation of this living being that is the human being, all its history, has happened to guarantee its survival, first as individuals and then as a species. Or, more accurately, first the species because the individual is worth little. This is the basic structure.

How do I perceive the world? Well, I see the world in colours. Even though colours don't exist. Science has shown us this and here you have Javier Montserrat, who is a specialist. Colour is the construction my brain makes of a reflection of certain wavelengths. As I have receptors for such wavelengths, I construct something which allows me to differentiate better between what is ripe and what is still green, what is one shape and what is another. And this capacity to make distinctions (although there are many animals that can live without colour) is what has allowed me to survive over the years. This is very important for understanding that the same I am saying about colour can be applied

to movement, because we have an OB5 which allows us to see very well when something moves from one place to another, but if we did not have it, we wouldn't perceive movement in any other way than with the rest of our cognitive abilities. I would be able to construct algorithms to explain the movement from one place to another in mathematical terms, but in reality the movement would not exist. And so forth with almost all characteristics. The structure and the interpretation codes allow us to say reality is as we perceive it. If another being came here after 3,500 million years of evolution on a planet that is not in this galaxy, it would make a different construction with these electromagnetic waves. It would construct a world so totally different in terms of reality that we would say it was a totally different reality altogether.

To challenge the audience even further, I would like to explain my view of how reason was constructed. In my opinion, this is such a simple process that you may be shocked by what I am going to tell you. In the last 2 to 4 million years, the few Australopithecus and Homos that were about out there only used their brains to struggle against the environment and guarantee their survival. Let's consider the glaciations. Suddenly Man has found himself with a brain which has not needed to struggle against the environment to survive. Agriculture appears, we become sedentary, we increase in number, we look at each other and we use the brain (some structures, some circuits) that was previously used for a very specific function (that of fighting against the environment and surviving), for another function, for cognition, that is, to reason. This is my hypothesis, but obviously it is only speculation.

Professor Cela Conde: I would like to reply directly to your question by emphasising the idea on the difference between the 7,500 million people. I'm going to give you an example, but then I'm going to challenge you so that you refute it. The question I'm going to ask you is the following: What colour is this wall?

Member of the audience: Supposedly it's brown.

Camilo José Cela Conde: Brown. Is there anyone who thinks it isn't brown? (*Silence from the public*). Somebody say «no», please.

Javier Montserrat: No, it's yellow.

Camilo José Cela Conde: Good, fantastic, we dramatise the differences somehow, but it would be very unlikely that anyone would say «3.1416» or «the day after tomorrow». In other words, in the particular difference there is a basic, general interconnection regarding a way of interpreting reality that gives different results but via a process which is the same. There are no processes that are essentially different (although there are especially different ones), as much as we might think we are talking to a person who has absolutely no sense of reality (let me make it clear that I am not including pathologies or mental problems, I am referring more to the character defects that we all recognise in our neighbourhoods, in the students in our class and in our own work colleagues).

Now I would like to introduce the subject of personal hate. I think that what Paco (Francisco) has said is absolutely true. That is that our brain evolved for one thing and suddenly we find that the application is another. I would like to propose what people much more intelligent than me (such as Professors Poli and Walach) maintain, that just maybe is the result of collateral damage. Let's see. Our mind is able to manage transcendental concepts specifically derived from this common process which allows us to communicate on a level so high that self-reflective phenomena have appeared.

As philosopher Daniel Dennett explained, we are intentional third level systems. That means I have the ability to understand that the two professors sitting next to me at this table have a theory about my mind in the same way I have a theory about theirs, in such a way that I am able to tell by their look that they think I am an idiot. Then, as it goes, we have got ourselves into an explanation that goes a lot deeper than it was supposed to,

which was to discuss with them both the fruit which has ripened early, which is essentially what my brain adaptively led me to. Another example would be to decorate myself with certain colours which would give me a greater advantage in social relationships, for attracting females, for example. In short, a series of circumstances were produced which led the mind to evolve in such a way that we are able to introduce transcendental concepts and we ask ourselves what happened before we were born, and we don't worry about it much. However, we also ask ourselves what will happen after we have died, and that really worries us a lot. In my opinion, this is an essential paradox of the human mind, which is able to ask questions that it cannot answer.

Let me explain. I often give the example that minds are not omnipotent. For example, we believe that cockroaches don't know how to do differential equations. Now, why do we presume we have the ability to understand the world in holistic terms? What we do is make holistic interpretations of the world in a way that, in my opinion, is collateral damage. My point of view is that what we call culture and civilisation is something that we have achieved precisely by negating this principle. Scientific development is based on reductionism. You will not find a scientist who considers holistic explanations for anything. This very week, *Neuron* magazine has explained how the use of an antagonist as an endogenous opiate receptor allows the placebo to use a very similar mechanism to medicine to prevent pain. Does this mean we have explained pain? Not at all. Does it mean that we have explained what the pain felt at the loss of a loved one could be? Absolutely not. If that were so, we would be able to explain why when a small child has died we cling to the belief that once we have died we will recuperate our relationship with him. Not only have we not explained this, but we will probably never be able to explain it. Why? Because we are primates that appeared in the Rift Valley with abilities that allowed us to distinguish between ripe and unripe fruit. And little else. Kant explained that we can only interpret the world through the categories of space and time, right? Well, there is absolutely no sense in asking ourselves what there was before the Big Bang, because if time didn't exist then it is something which is absolutely incomprehensible for us. However, our mind is so fantastic that it has allowed us to develop differential equations which enable us to interpret the world around us. And it turns out that the world is much stranger than we could have possibly imagined.

Ideas as amusing as Shrödinger's cat appear and we have to confess that we are unable to understand this world, the quantum world. It clashes head on with all our most basic feelings regarding the relationship between cause and effect. It implies the existence of something that would highly irritate Descartes: action at a distance, but not action at a distance in terms of universal gravitation, action at a distance regarding the collapse of wavelength function, in such a way that the particle, or part of it thereof, is in Alfa Centauri. Ladies and gentlemen, I am wholly unable to understand this world and maybe all philosophers should just be shot as a more rational system for solving intellectual problems. This could be a first proposal from the seminar.

JAVIER MONSERRAT: If I may, I would like to answer the question asked regarding the fact that everybody has their own view of reality. Well I believe it is so.

COMMENT FROM A MEMBER OF THE AUDIENCE (THE SAME ONE WHO ASKED THE QUESTION PREVIOUSLY): I would like to link this concept to system theory. If system theory says that reality is a system, but each of us perceive this reality differently, it seems we cannot talk of the existence of a single reality as each of us has his or her own reality. This is supposing, of course, that reality exists.

JAVIER MONSERRAT: Yes, regarding what you have said, I would like to add the following. Science today has an evolutionary viewpoint. In other words, we do not explain Man via

fixed, universal and necessary structures of the mind, as Kant might for example, but we say Man has a mind which evolves over time, and what is currently happening is that this evolution of Man's mind is trying to form an interpretation of what he is seeing, of what is out there, and it is overwhelming. This is what is we might call reality in epistemology. Reality is not something known, but that reference point which tells us that we are in something and we must find out about this something and conceptualize it. Of course, throughout history we have been witness to the evolution of different interpretation systems, philosophies, and ways of perceiving and understanding the world. The origin of science itself (the appearance of reductionism as Professor Cela said) is a way of understanding the world. There are scientists today who think that this is not the right way to look at it, that there are other perspectives. In the field of biology, for example, there are many people who are not reductionists. What does this mean? Who is right? Neither one nor the other. We are immersed in a search process and, when it comes down to it, reality is an enigma. What happens is that people form interpretations. Therefore, Professor Poli's interpretation of understanding life and the mind in terms of system theory is precisely that, an interpretation, which is congruent with many things. For example, it is congruent with the fact that we ask ourselves how the human mind works. It is congruent with the development of an epistemological theory, of positivism, of Popperian systems… We see how science is an analysis of systems, of structures, of connections between things… All this in an attempt to find unitary explanations. This is what we are all searching for. But is it, perchance, an absolute truth? Are there other explanatory alternatives? What is reality? Well reality is something open, it is an enigma, a reference point which triggers the dynamics of the mind. Therefore I agree with you when you say that each one of us creates our own reality. There will be some who create it in terms of systems, and others who don't. And there may be people who create their reality in reductionist terms and those who do not. And science is clearly evolving. Who knows where we'll be in 150 years time.

Francisco Mora: I'll be in my grave.

Javier Monserrat: I will too, the three of us will…

Juani Guerra: ***The reluctance of human beings to admit reality.***

A question from Juani Guerra: I wonder why human beings are so reluctant to admit to their reality. We are always talking about reality or the mind as a complex adaptive system, which connects with the idea of reductionism. I believe that in both science and art and literature we have begun to reduce to find what is conceptual. We have reduced language enormously since the Enlightenment. Centuries have passed and we are still reluctant to be real about cognitive reality. Neural correlates could be found for this refusal to access reality in an open and self-organising way, as those who write about creative processes have commented a thousand times. This is a flow, there is creative chaos, we don't know where it organises itself, but the structure of meanings emerges. My question is, why do we keep denying it?

Camilo José Cela Conde: I could not design an experiment for neuron activation insofar as the variable I would have to isolate would necessarily be so simple that I don't think a question as complicated as the one you have asked could be answered through simple variables. In other words, if I asked a subject the question: «what can you tell me about the almost universal tendency to deny that we have evolutionary established limits for the interpretation of reality?» to try and see the brain activity via magnetic resonance imaging, PET or magnetoencephalography. I am almost certain that I can already tell

you the result. The whole brain is activated. We can use magnetoencephalography to identify the neural networks involved. What we know how to do at the moment is identify neural network responses to very, very simple variables, so we would need to find a simple question that expressed that enormous difficulty. However, I don't believe that this is at all easy. I don't even believe it can be done for what Camus said was the most basic human question: suicide.

Comment from Francisco Mora: As Hume said, not even God can make the decision of suicide.

Camilo José Cela Conde: I do not believe that personal position with regards to the question of whether to commit suicide or not could be reduced to a simple variable. And it seems that this is quite an immediate question that does not lead to much dispute, am I right?

Juani Guerra: Yes, I agree. Maybe it helps to define very specialised functions. For example, a linguistic study has been made of a surgeon and a butcher, investigating the terrible complexities of the conceptual dynamics released. The question is what happens when the surgeon or the butcher makes a cut or incision?

Camilo José Cela Conde: There is no doubt in my mind that the inferior cortex would be activated. Look, I would like to explain this to you in a paradoxical way. If you want to understand human nature, don't study anthropology. Read Shakespeare, because that will help you understand it a lot better. You will find much more out about what it is to be human in Shakespeare's plays than through anthropological studies, because anthropological studies cannot reach (at least not yet) that fine degree of analysis. Quite simply, we do not have the means to achieve it. Think about what I told you before that has been a marvellous achievement for my research team. I know what happens in the brains of 10 men and 10 women (and I say only 10, not 7,500 million) when I show them 300 images (not the 30,000 images that we see in a day) and, when I show them each of the images, I ask them to tell me if they think they are ugly or beautiful, not the enormous amount of subtleties we are faced with in a painting by Bacon, for example. In other words, the reduction is brutal. Therefore, it would never even occur to me to state that I had located aesthetical perception. It would be ridiculously trivial and vain of me to think that. The only thing I have managed to do through experimentation is put a thin coat of varnish of information on certain aspects that are involved in aesthetic perception. And that is all. And why don't I do anything more interesting? Because I don't know how to. And I'll tell you something: in conversations we had with Alberto Portera before carrying out our experiment, Alberto said: «You are mad, you aren't going to find anything. The brain as a whole will be activated. You won't be able to detect anything at all». And Alberto Portera is a very competent and intelligent person, whose feet are much more firmly on the ground than ours. That is to say, that in the beginning the only way to obtain scientific evidence is through such a brutal reduction of the original problem that when we try to go back to it in its original rich state, we get lost. It is a shame, but I think the most honourable thing is to recognise that this is so.

Francisco Mora: I would like to go back (even if it is only for 30 seconds) to an earlier observation made by our colleague in the audience which impressed me. I am referring to the question about what makes humans not accept reality as it is. I think this is a very interesting question because, at the end of the day, it has to do with consciousness. That is, with the fact of realising what is around us. And it is true, it is very difficult in a Western society like ours to accept this reality. What is it that makes us constantly seek alcohol? What makes us turn to drugs? In my opinion this is an escape, in some way, from this reality.

COMMENT BY CAMILO JOSÉ CELA CONDE: Yes, it's an escape from the *horror vacui*.

FRANCISCO MORA: We turn to ideas full of emotion, and that is God.

CAMILO JOSÉ CELA CONDE: Do you realise you just said we also have to shoot the theologians?

FRANCISCO MORA: No, no, God no. There are a lot here and we'd have problems. We'd get burnt. Well anyway, I'll leave it there. This is actually a disquisition that I bring up in one of my books. Excuse me Javier, over to you. I know you are wanting to speak.

JAVIER MONSERRAT: Professor Alberto Rosa asked to speak first.

ALBERTO ROSA: ***The influence from the environment. The Baldwin effect.***

ALBERTO ROSA: Well, first of all, thank you both very much for everything you have told us. I noticed you gave an explanation for the structural change that has taken place over time. I mean the structural change in the human brain. Now, I don't believe you have given us an explanation of how this structural change took place. From what I know of the subject (which isn't much) there are neo-Darwinist type interpretations, along the lines of Wallace, but my interpretation is more in line with the «Baldwin effect». It seems to me that having to choose between one interpretation or another has enormous consequences, for psychology, for example. I think it was Professor Mora who ended with a question: if we have had the same brain for 100,000 years, how is it possible there have only been cultures during the last 30,000 years? In my opinion, the answer for the question on structural change will allow a very different answer for Professor Mora's question. In this sense, I think that if the «Baldwin effect» was also accepted, then maybe the first supposition that Professor Cela Conde spoke of (that the mind is a functional state of the brain) should, perhaps, be rejected. I am more inclined to take the line of Gerald Bruner, who says that the mind is to be found in the environment, that it is not only in the cranial cavity.

CAMILO JOSÉ CELA CONDE: Yes, the mind is collective.

FRANCISCO MORA: I don't accept that.

CAMILO JOSÉ CELA CONDE: It's a polisemy; we are just playing with words. When we talk about the collective mind, I think we are using metaphors.

FRANCISCO MORA: Ok, yes, but I think Professor Rosa is going a step further.

JAVIER MONSERRAT: Alberto, explain the «Baldwin effect» to us please so that our audience can understand it.

ALBERTO ROSA: The «Baldwin effect» is the effect the learning of skills has on the ability for survival of an organism, which would have, as a consequence, the possibility of a structural change as a consequence of its success or the absence of adaptive success. The neo-Darwinist explanation opposes this, saying that it is a change in the genetic code produced by chance, which produces a radically different speed of evolution. I think this is very important because of the reasons given previously, but also because of a matter that bothers me a lot, which is the appearance of symbolism, the notion of the symbol itself and the relationship that may exist between symbol and sense, and between conventionalisation and the collective or individual symbol, I don't know if I've made myself clear.

FRANCISCO MORA: I think you've made yourself perfectly clear. This is an interesting point for debate. I see the problem in the following way. The matter of the 100,000 and 30,000 years was clearly explained by Professor Cela Conde. As my colleague said so well, things change substantially depending on whether we are thinking in European or African terms.

Camilo José Cela Conde: There is a very interesting doctoral thesis from a Professor at Yale, Professor McBrearty I think she's called, which filled a whole issue of the *Journal of Human Evolution* (in 2000 if I'm not mistaken) and which looks to Africa for the same evidence that appears in Europe some 30,000 years ago. It was shown that the ochres, or use of pigments, are documented at 150,000 years ago. What happens is that the modern-looking humans did not use pigments in Europe until 30,000 years ago. Why not? we might wonder. Well simply because they weren't there. The first modern-looking humans appeared around 30 thousand years ago. When they were in Africa, however, they did do it, but not cave paintings, they did other kinds of painting which we have not discovered yet. Probably, or at least in my opinion, they painted their own bodies. The paintings in Africa are from a later period, they are around 50,000 years old.

In any case, I do not wholly agree with Professor McBrearty's thesis, the zero hypothesis of which is that the element of symbolisation has existed throughout the existence of Mankind, from the modern-looking humans. I think this zero hypothesis needs to be amended. In other words, the tendency towards symbolisation existed while there were modern-looking humans, but the crucial question is still there. What appeared next? In my opinion, the easiest way to explain it is the «expensive tissue» hypothesis put forward by Leslie Aiello among others. It is so difficult to fix increases in brain weight over the process of evolution by natural selection because the metabolic costs have been really high. So much so that the only explanation we can give is that of «significant adaptive advantages». But of course we are chasing our tails, are we not? We are saying that the brain evolves because it is useful and it is useful because it evolves. We are faced with a circular explanation, something that is very common in the field of neo-Darwinism.

However, I would like to clarify the idea of the power of the Baldwin effect because it has an exceptionally good neo-Darwinist explanation as far as (as is so well known) no kind of change in the genetic material is needed to produce new traits in genotypical terms, because recombination is sufficient. As long as we are talking about a species that reproduces sexually, genetic recombination is sufficient to cause the appearance of a multitude of new traits in each generation. Does this mean a rapid turnaround or gradual evolution? Unfortunately the fossil record is so limited that we cannot answer that question. Staunch neo-Darwinists such as Ayala laughed at Stephen Jay Gould's thesis on sudden evolution after a period of rapture, saying that the only thing it showed was that I have a fossil now and another 700,000 years later and they are different. Well, of course. But as I haven't got the ones from in between I can't say anything about what the process was like. For that reason, I believe that it would be a good idea to offer alternatives because a dogma is the most boring thing in the world, don't you agree? Nevertheless, if the dogma explains something really well, I don't think it's necessary to create an alternative. Especially through the basic question which people like Le Coral would ask: these changes (unless they are epigenetic), how is that information introduced into the DNA?

Francisco Mora: The topic clearly has to do with epigenetics and that is something very recent, from over the last five years. We are talking about the transfer of acquired characteristics. That is to say, we are entering a Lamarckian evolution as opposed to the classic Darwinian evolution. There is no need to change the genome structure, just simply methylate some of the bases which make some genes in the corresponding proteins manifest themselves or not. And this happens according to the lifestyle you lead. To say that what I do does not affect my child is a lie. The fact that you smoke can have an enormous effect on your child. Or maybe it does not manifest itself in your child, but in your grandchild. Or not in your grandchild, but in your great-grandchild. As we have

seen in those generations of women in Holland after the hunger there was during the war…

CAMILO JOSÉ CELA CONDE: I will always blame my father. What happened 3 or 4 generations ago doesn't interest me at all, but I know what my father did wrong. In fact, I have reproached him for it many a time. So Francisco, it would be better to limit your explanation to just one generation.

FRANCISCO MORA: In any case, it's a biological fact, it's really out there, and it's creating a new social theory, one in which human beings are an incredibly interconnected network. I can go up the mountain, smoke or take drugs, and then come down and have sex because absolutely nothing will happen. But let's not get this wrong. Something can and will happen and my actions will have repercussions in my children. How? We aren't sure. What we do know is that it has significant repercussions in the body, in the soma. We are now understanding that there are also repercussions in the brain and in behaviour, which is something quite dramatic. We could say, therefore, that the responsibilities of human beings are increasing.

CAMILO JOSÉ CELA CONDE: Let's think about a matter which is causing us problems. I was very happy that you spoke about creativity, because what we are trying to do now is see the differences in the brain, during the creation process, between artists and people who are unable to create, such as myself. Well, we are confronted with a tremendous problem, the effects of non-endogenous opiates. I mean if they have smoked marihuana, it lasts for a month in the brain. Could you be sure that an artist hadn't smoked a joint in the last month? We cannot be sure of that at all. But let me go back to the matter not of epigenetics, but of exterogestation. The brain is shaped over the 7, 8, 10 (...) years after birth. It does this in a very specific social and communicative environment. What happens there is bound to influence the maturing process of the brain and the cultural world is profoundly Lamarckian. That is to say, a huge amount is inherited. In other words, it is completely impossible to distinguish genetic aspects from cultural aspects as regards the maturing process of the brain. If we then add epigenetics and blame to this (my father didn't watch what he ate and he smoked), I don't even want to begin to explain how complex the phenomenon is for trying to find simple results.

FRANCISCO MORA: I would like to add something regarding the comment made by my friend Camilo when he said that the brain is shaped up to 18 years of age. Maturity, that is the total myelination of the prefrontal cortex (which provides us with the moral values that you have presented here, as well as important social decisions), is not completed until 27 or 30 years of age approximately. What does this mean? It means that the clarity of information processing is not the same as that of an adult as the connectivity cables are not isolated.

CAMILO JOSÉ CELA CONDE: There is a really beautiful thing about this. I am referring to the fact that we only progress or regress. When we have reached the peak, we begin the decline.

FRANCISCO MORA: Because we have changed the genetic programme. But not only the myelination. At the 27 years of age we spoke of, enzymes we didn't have before appear and stop appearing, such as acetylcholinesterase, which restructures the functionality of certain prefrontal circuits. This is new, but it's there. It means that when we say that someone who is 24 or 25 is definitely of a specific opinion, there are tests that can tell us this isn't true. That this information is available is obvious and it has very significant implications. So much so, in fact, that the U.S. is considering changing jurisprudence. This is why neuroscience is being talked about so much and it is said that within a few years there will be no leader that does not have a neuroscientist as an advisor. I mean

that in some way the profound knowledge we have of the neurodevelopment of the brain will become more and more important. And I don't even want to begin to talk about that neo-architecture which has arisen…

[*End of recording. For the last half hour of the debate a summary has been made from some notes taken during the event*]

... (at the end of Mora's comment): The environment has a lot of influence.

Camilo José Cela Conde: It is very unfair. If one is raised in a poor family, for example, in which the parents are obese and do not offer any intellectual stimulation… the result is totally different.

Alberto Rosa (said something about neo-Spencerism)

After the participation of Alberto Rosa, Javier Monserrat, acting as moderator, said that only three more questions would be taken: those of Javier Leach, Mari-Sol D'Luis and Christine Heller, who had already requested to speak. Mari-Sol declined, however, as she believed her question had already been answered. The third question was, therefore, granted to Joâo Pinto. The professors had to reply after having listened to all three questions.

Javier Leach: *Reality as a plurality of systems on different levels*

Javier Leach commented that in the context of systems and globality theory (entanglement) he was particularly interested by what the speakers had to say about questions that cannot be answered. Regarding formal logic, it has been established that there are questions which cannot be answered. We can then take a leap forward to the empirical, to what reality is. But there is also another leap that can be taken, a leap towards beauty, to the metaphysical... We have more basic levels, but then we have to leap to levels where we do not understand everything. He then asked the speakers their opinion on this vision of reality as a system, when we think of a plurality of systems on different levels. For example, in their line of work, a physicist or a doctor deals with certain types of experiences, but they can also have experiences on another level, such as a religious experience or hearing the sacred Word…

Christine Heller: *Epigenetics and artificial selection*

Christine Heller proposed that the question of epigenetics should be looked at more closely. All cultural phenomena have a high degree of influence on human beings. In fact, now that natural selection is not applicable to our species, can we talk about artificial selection? The traditional way of changing genes is probably very different from the way it is done now.

Joâo Pinto: *Reality as formality and the influence of external factors*

Joâo Pinto pointed out that we get lost in the debate of what reality is because we cling to contents. Zubiri makes an important distinction: reality is a formality rather than a content, which is more in keeping with the idea of reality as a system. In accordance with this concept we can refer to reality as much in the case of electromagnetic waves as in the case of the voices heard by a schizophrenic. Another important question is the development of the human brain and its tremendous dependence on external aspects from the very moment of fertilization, a matter already being treated in bioethics.

Perception, for example, can be taught, as can be seen in the incredible capacity of the Eskimos to distinguish between different tones of white (up to 23 different tones). Aesthetic experience is very different in different cultures, for example, classical music needs a certain amount of introduction… As regards epigenetics, it is important to remember that we find ourselves in a collection of sensory neural networks.

Camilo José Cela Conde pointed out to Joâo that if a project they have presented is finally approved, they will be studying this influence of education, but at the moment the question cannot be answered.

Francisco Mora explained that sensorial perception responds to the supreme law of survival. The 23 kinds of white perceived by Eskimos correspond to a very important value in their environment, as they can quickly distinguish between ordinary snow and an enemy such as the polar bear. As regards epigenetics and culture, he stressed that what is inherited by children from their parents is clearly there and influences the brain. To enter into a discussion on this subject we have to be very clear what we are talking about.

Camilo José Cela Conde pointed out that, according to epigenists, it will be 10 years before we see any changes.

Francisco Mora then replied to Javier Leach regarding leaps, levels and emergences, saying that emergences have to be understood from the simple view of a scientist. For example, if water emerges from oxygen and hydrogen, we do not consider any mysterious forces are at play, even if we were not at all sure what was happening. Today we know exactly what a neuron does, but it is not clear what is happening if several join together. In the sensory reality we are talking about, God does not exist, given that he cannot be seen, heard or touched, and if anyone claims to have seen him they are sent to a psychiatric hospital. According to this professor, God is an abstract, an idea, in the process of which is the human being. Faith is holding on to this idea.

Camilo José Cela Conde added that this is as real for the person who believes it as the voices are for the schizophrenic who hears them. He then told the story of a case of a psychiatrist in Dr. López Ibor's team who developed schizophrenia when he was fairly old and who declared he really did hear the voices. He also reiterated that, according to Berkeley, everything that exists is a continuation of our minds. So this professor prefers the position that we are not able to explain anything. Gödel killed the mathematics principles, and so we had to fall back on metalogic.

Javier Monserrat eventually brought the session to a close by asserting that reason is an instrument for survival. The only thing reason has created are survival systems, whether they are philosophical systems, religious systems or something like quantum mechanics.

IV. JAVIER MONSERRAT CONTRIBUTION: *How to understand the physics of the brain? The scientific explanation of reason depends on it*

We accept that things are really like Mora and Cela Conde have presented them. But even so, we also believe that if we ask how the brain produces the rational activity of the mind, we must take a theoretical position (or devise a response) to certain scientific problems, as it is required by the epistemology of science. These problems and possible solutions do not question the view held by Mora and Cela Conde. They are consistent with them. However, they represent,

in our opinion, an important part of the problems being discussed today in relation to how the brain actually produces human reason. The requirement for scientific deepening is epistemologically correct.

Before entering the exposition of the content of our own contribution to this session of the seminar, we begin by some remarks on the papers of Mora and Cela Conde. This way we can better explain why we believe that understanding how the brain produces reason now requires a reflection on the issues related to the «physical support» of brain activity. It is clear that we are only speaking of science in general as a whole, because scientists are free to keep within certain limits their personal study of the facts and the solutions they propose.

1. The evolution of the human brain

Brain growth in humans, the encephalization quotient, has been scientifically described in evolutionary terms. This means that human beings have a brain seven times heavier than that which would correspond to their actual bodyweight. But, in humans, evolution has not only increased the volume of the brain, it has also changed its organization in the differentiation and functional specification of its parts. Evolution has thus changed the human brain itself and has changed it qualitatively, because of the appearance of new types of neurons. These neurons have been localized in brain areas more related to mental functions, more characteristic of the human species. The anatomic brain changes have been producing gradually a functional transformation of animal psychic activity. This has led to the emergence of the human mind and its rational functions. There have been crucial transformations in the areas of language comprehension (Wernicke), in the development of the occipital areas of vision and in the growth of the frontal and prefrontal lobes associated with higher activity of the mind, as professor Mora explains.

Science is working today within the general assumption that mental activity, animal and human, is caused by complex systems activation of neural circuits located in different areas, but interacting in real time to produce our psychic experience. The correlate of these circuits is a variety of psychic activities: different sensory modalities (senses), emotions, memory, knowledge, behavior plans, automatic activation of sensations (signals) with learned response programs, etc. Everything is geared to survival, optimal adaptation to the objective environment. Therefore reason is also a higher activity, which appeared in humans, which is based on specific circuits that allow, as noted by Mora, abstraction, language and symbolization.

2. The emergence of reason in the origins of mankind

Cela Conde also assumes the general course of science, as described by Mora: that mental activity is a counterpart produced by the activity of the brain (nervous system). The correlation 'mental activity / brain function' is sufficiently established

by scientific evidence. That mental activity is entirely produced by the brain's activity is a more risky tenet, with less evidence. Cela Conde insists that, in speaking of the identification of the evolutionary process and the mental machinery, we must distinguish what are hypotheses (just guessing, conjecture) and what is scientific evidence. Professor Cela Conde has consistently expressed his intention to move the most in what can be said by the scientific evidence, reducing speculation as needed.

For Cela Conde specialized literature is built from the admission of some initial axioms. The first one assumes that the mind is a functional state of the brain. The second one assumes that cognitive activity stems from the activation of neural networks. The third that neuroimaging techniques detect neural network activity, leaving aside any doubts which might exist in regards to it. According to these precautions, Cela Conde thinks we can detect how mental activity (especially in his research on moral judgments and aesthetic preferences) takes place in our brains (but reaching only limited information about it). Neuroimaging techniques (the technique applied by Cela is magneto-electro-encephalography) can find (with some variability and specificity) which parts of the brain are activated as a correlate of mental activity in moral judgments and aesthetic values. Professor Cela also comments various paleoanthropological conjectures about the emergence of modern man's psychic activity. It took place probably in the *Homo sapiens sapiens*, who entered Europe from Africa about 30,000 years ago.

3. Reason as scientific explicandum

To find the causes that led to the evolutionary emergence of reason is a process of scientific knowledge that has, as always, two points: first to describe the fact that needs to be explained (*explicandum*) and second to try to know the causes that have really made it possible, arguing from the scientific evidence we have (*explicans*). When trying to build scientific explanations of the psyche we always need to be well founded on the phenomenological experience (*explicandum*). So we can say that the human mind has *de facto* a phenomenological capacity for abstraction, language, symbolism. We can continue the analysis of the apomorphies of John Carroll and add, as Cela does, moral judgments and aesthetic preference. Therefore we have a description of how it is in fact the human species, how their psyche works and what differential characteristics with the animal world have made possible the «human» world.

However, in philosophy and psychology, and even in epistemology and science itself, many phenomenological analyses have been proposed on how the human mind does in fact work; in particular the personal and social exercise of reason. In part, the previous sessions of the seminar have offered various perspectives on elements of how human reason is as individual and social fact. Poli has done so by telling us that reason is a systems analysis (which is caused by the nature of life.) Nickel has been telling us that mathematical reasoning in the formal sciences appears in fact to be a free and creative imagination of formal worlds.

Walach has done the same by considering that the psychological experience of our mind responds to the principle of complementarity: it is a fact that our mind (and our reason) is immersed in a holistic psychological experience of the body and the world. Curado has reconstructed a deep epistemological analysis of rationality that we find in human knowledge; both in its precarious achievements and in its claim to truth. For the most part, the epistemologies (such as positivism or Popperianism) are descriptions of how it is in fact the activity of reason in science. The same can be said about the phenomenological analysis of the ethical and aesthetic judgments (remember Kant or Anglo-Saxon analytical philosophy).

Therefore, what science has to explain is the great complexity of human mind, as it is presented in the personal and social experience. The operation and the nature of reason is based on the complexity of the unified sensation, emotions, knowledge and representation, memory, and the attentive processes of the psychic subject, categorization, abstraction, thought, language, symbolism, ethics or aesthetics. The fact of how human reason operates has been described in the context of science, epistemology and psychology (among other disciplines).

4. Reason as the scientific explicandum of human sciences

The phenomenological experience of reason occurs in the context of some basic experiences (partly common with higher animals, as we infer). These experiences have been set by the human sciences (vg. by psychology) and must be explained scientifically (getting to know their causes). We refer, in essence, to three: the experience of the unity-of-consciousness, the holistic experience of one's body immersed in the world and the experience of uncertainty (or the choice). Reason is a process that results of the psycho-bio-physical activity of human beings. Therefore, the explanation of reason depends on the explanation of these experiences.

Therefore, the actual objective of the human sciences is to explain our phenomenological experience of reason (which has the nuances that I have stated). This target is justified in epistemology. To this end, science will argue on the basis of objective evidence (which, according to Popperian epistemology, is always a «human interpretation» subjected to criticism and review). Based on the facts or evidence, science always is necessarily speculative, constructing hypotheses and assumptions that enable it to obtain a representation of the profound nature of things. Theory construction (partly speculative) is an essential part of science. It is irreplaceable because they are theoretical speculations that guide the continuous production of knowledge.

5. The link between mind (reason) and brain

Professor Cela Conde, following Chomsky's analysis, mentions that we relate three things: an external object (say, the physical world), the cerebral organs

(say, the bio-neurological world) and knowledge (say, the world of representations produced in the psychic unity-of-consciousness). They constitute the psycho-bio-physical unitary experience of our body. The psychic world (the knowledge) and the experience, in my opinion, are not only accessible to common sense (Cela Conde & Marty, 1998), because we build today the human sciences from the conviction that mental activity is produced by the psycho-bio-physical activity of the nervous system (brain). Relying therefore on the empirical correlation between mental activity and specific activation of the cerebral organs, we can establish the hypothesis, fundamental in science today, that mental states are produced by the brain and constituted by the functional states of the latter. Man is his psycho-bio-physical entity and therefore makes also sense to say that «man is his brain»: his sensation, knowledge, emotions, etc. This hypothesis, consistent with strong empirical evidence, is accepted by Mora and Cela Conde, and I endorse it without reservation. Cela's research on psychic activity in the ethical judgments and aesthetic preferences shows, in fact, these correlations. But, as indicated, Cela proceeds cautiously, saying that we cannot go beyond the mere observation of correlations.

However, the sentence «man is his psycho-bio-physical entity, that is, his brain» is very general. Usually it means: that mental states and activities are produced by the activation of circuits (engrams, neural networks) registered in modules (sensory, emotional, linguistic, cognitive, etc.) closely connected by synaptic connections (electrical, chemical, neurotransmitters, etc.) But neuroscience is built from other assumptions, based on empirical evidence. These are: that the nervous system (neurons in their real constitution and their functions in interacting systems) are «the biological world» and, ultimately, «the physical world». This means that the neurological world in its establishment and its operation depends on the physical and chemical laws (i.e. the nature of the physical world). This assumption of science is inevitable, in strict scientific epistemology, that's why neurology (the human sciences, including psychology) need to connect with physics in an interdisciplinary framework.

6. The psycho-physical problem

It is legitimate for scientists: a) to accept our mental activity as presented in our ordinary life and b) to understand their work as limited to the verification of the circuits, modules, interactions, systems, which are the basis of mental activity. Or to consider simply the neuro/physical correlations (as Cela Conde does in the brain records by magneto-encephalography). That is, they may be dispensed methodologically to address the interdisciplinary problem neurology/physics. The medical/neurological practice does not need, at least for now, to address this problem, neither in clinical nor in surgical therapy. However, in the whole of science is also legitimate and necessary, and in the end inevitable, to consider the explanation of the simple sentence «man is his brain» from the insights offered by the physical sciences, because «the brain is physical».

Therefore, what happens in the brain is physical. If you want to know what happens in the brain, we must ask: what is the physical world? What kind of interaction takes place in the physical world? The problem is that physical science now provides two images of the physical interactions: classical mechanics (discrete entities, spatiotemporally localized and with a deterministic serial interaction) and quantum mechanics (holistic, indeterminate, being spatiotemporally diluted). It is clear that a classical picture, a quantum picture, or both in combination, of «what happens in the brain» can lead to different explanations of «what happens in the brain» and of the nature and origin of the human psyche (and reason). This variety of interpretation can be seen in the history of philosophy of mind.

Human sciences always have one goal: to explain what we see (*explicandum*) from their causes (*explicans*). It is possible that if we propose a certain set of causes as explanatory system, then it is difficult to understand how this causal system can produce «what we see» (the phenomenological experience). This is what actually happened and is called psycho-physical problem (reconciliation of physical causal system with the phenomenological experience of the psyche). The problem has been that some psychologists, philosophers and neurologists have not kept within the general sentence (uncompromising) «the mind is a functional state of the brain», but have given an interpretation of brain from classical physics. This has been a problem and produces a split among scientists: those who accept a mechanistic and deterministic image of mind (today a robotical or computational image) and those who are reluctant to admit that the phenomenological experience has actually been explained by this type of classical physics. The first is reductionism, widespread in the last century. The latter have two choices: either to think that the applied physical model, the classical one, is not sufficient and should be corrected (or complemented), or to think that our experience in the unity-of-consciousness is not caused by the physical world (what is in fact dualism).

7. Classical and quantum world

Current physics is monist and recognizes only one type of matter. It's the matter that ultimately was produced in the *big bang*: a very high energy radiation remains in the universe (although mostly processed in classic matter).

We know that the only physical reality, when cooled, produced a certain kind of vibration or particles (with an antisymmetric wave function) which hardly could be fused together. We speak of protons, electrons and neutrons that make up the classical matter (fermionic). Two electrons in a single atom do not merge, but retain their individuality in different orbitals. Although the particles are structured into other entities (vg. atoms, molecules, physical bodies in classic space-time) they maintain their individuality, a distance between them and their spatiotemporal location. The so formed world of objects or entities (celestial bodies, materials, biological objects…) is the classical world described by Newton, a world in which its entities have among them a set of interactions described by

classical physics. The classical world is ultimately in preference the world of mechanistic, deterministic, discrete entities. In it the effects of (electrical, gravitational) «field» are in a certain sense an anomaly.

But radiation also produced another type of vibration with different properties: those waves/particles which could fuse together easily. Unitary wave states are filling fields of reality in which individuality cannot be distinguished. This kind of physical reality, or particles, are called bosons (in memory of the first Bose-Einstein condensates). It is matter (with a symmetric wave function) whose interactions respond to stranger principles (scientifically proven by quantum mechanics), which are among others: quantum coherence, superposition, uncertainty and action-at-a-distance (non-local causation and PDR effects). These properties are not met among the classical macroscopic world objects. In this world of classical fermionic matter certain type of vibration has been «trapped» in the material entities that we see in the macroscopic world of our experience.

8. The classic explanation of the brain

Let us return to the sentence: «man is his brain» or «the mind is a set of functional states of the brain». If we move in this general tenet, without deeper scientific explanation, we can admit an interaction between brain and mind (or psyche). The psychic world is that of our ordinary experience (a world therefore human, not robotic or deterministic), meanwhile the physical world is the neurological networks or neural circuits that we describe in neuroscience. Therefore it is postulated, according to evidence, that the mind depends on the interaction of networks and neural systems. Also, on the other hand, states of neural networks depend on the psychic activity. But if we don't want to deepen the scientific psycho-physical knowledge, we move then in a position that has been qualified in philosophy of mind as «psycho-physical and interactionist agnosticism». We postulate a causal interaction, but we give up looking for their root causes.

But there are thinkers, scientists, who have answered the question: how to understand the brain in its constitution and in its dynamic role? The knowledge produced so far about the brain responds to a certain image. For many scientists it seems to lead to the conclusion that brain functions are based on classical interactions and reduced to them. Many authors have thought this way, according to the so-called «reductionism». Why do we tend to think so? Because what we see in the biological body and in the neural activity are only classic interactions: a) there are independent entities that are part of the fermionic «classical world» (bodies and biological systems, cells, neurons, genes, molecules, atoms, synaptic buttons, chemical-electrical nerve currents, jets of neurotransmitters, covalent and ionic bonds, etc.); b) entities that produce together a classic set of interactions that lead to form mechanistic, deterministic, robotics systems which today tend to be interpreted by computational models (serial or connectionist).

Now, if living beings (the brain) are purely classical systems, then the adaptive action (their conduct or behavior, ultimately, their life, and man's «human life»)

are caused or produced by a mechanical causal-deterministic system (classical). We know that some neurologists have revived in modern medicine a radical «determinism» that seems to fulfil these positions.

9. The quantum-classical explanation of the brain

Many scientists have not accepted the classic «reductionism» because it does not explain the phenomenological experience (and its properties: unity-of-consciousness, indeterminacy and holism of experience). The result has been either dualism or attempts to reconstruct the image of the physical world to understand how it could produce our world of human experience. These alternatives to a macroscopic-classical neurology would be the various schools of «emergentism», but above all, the «quamtum emergentism». The latter is based on an essential part of modern science: quantum mechanics.

Quantum emergentism is supported by the observation that among the phenomenological properties of mind and the interaction properties of matter in the quantum world there is a parallel or similarity: the unity-of-consciousness and holism connected with quantum coherence and action-at-a-distance (EPR effects) and the animal indeterminacy and psychic choice in humans connected with superposition and quantum indeterminacy. This gives meaning to the so-called Von Neumann-Stapp hypothesis: the hypothesis that, according to this similarity, causal explanation of consciousness should be sought in the quantum world. This hypothesis posits that, in living organisms and their interaction with the external environment, it would result that quantum states of matter would allow properties and functional consequences that cannot be explained by pure classical interaction systems.

The Von Neumann-Stapp hypothesis has been rejected by Christof Koch (by arguing the *boutade* that we should not explain a mystery, consciousness, by other mystery, quantum mechanics), but it has been generally accepted by biologists as prestigious as Stuart Kaufman. The Von Neumann-Stapp hypothesis is very general and uncompromising, but it raises a question: where and how would the quantum states take place in living organisms? This is the core of the problem. But it is possible to begin to investigate it: Hameroff-Penrose hypothesis is an example. It is only a proposal, but a complex one and well reasoned. It has been discussed, supported or rejected, or even accepted with reformulations. The Von Neumann-Stapp hypothesis does not depend on the fact that the hypothesis Hameroff-Penrose may be true or false, or should be reinterpreted according to knowledge that we do not possess.

Perhaps an example could clarify what we are explaining. Let's suppose the design of a real physical entity: a car engine. Its ontological and functional design explains that it can produce a mechanical force of traction. However, its design is not appropriate to explain the production of psychic phenomena (sensation, perception, intentions, etc.). Well, if we consider the physical entity of a living being in which only classical interactions take place to respond to the environment,

then this functional ontology would not seem appropriate to explain the production of psychic activity. It is therefore understandable the hypothesis that living beings are not only a classical system, but are, at the same time, a coordinated quantum system whose design may explain why psychic beings present specific phenomenological properties.

10. Edelman's classic explanation

In my opinion, the most serious attempt of a classic explanation of the phenomenological properties of consciousness is proposed by Gerald Edelman. This is not, however, an explanation in accordance with the generic «man is his brain» position, although similar to an interactionist psycho-physical agnosticism. Edelman is committed to show that the brain is a classic system and refuses the quantum explanations (he refuses, in particular, the Hameroff-Penrose hypothesis). Therefore Edelman agrees with a physics of consciousness understood in classical terms: a system of interactions (as we said before) that respond to the interactions that appear in the classical Newtonian world. However, the biophysical design of this classical system, is it appropriate to understand the production of the psychic world? To explain the unity-of-consciousness Edelman argues that the classical neural system describes a dense and complex system of entries and re-entries that connect between them in real time and are mapping all neural networks, in various forms. Consciousness may well (because of the dense web of connections) in a certain sense unify the different sensory modalities and psychic functions. To explain the «indetermination» (flexibility of animal and human behavior) he argues with the concept of «neural Darwinism». Given the immense number of possible networks, all stimuli should be selected by the choice of classical mechanisms or most appropriate circuits (neural Darwinism). There is a variable, born of complexity, which is decided by the performance of the unit-of-consciousness as a dynamic nucleus (core), one of the essential concepts of Edelman. The agency is undetermined by the same uncertainty of the huge network of potential connections in a particular case. The brain «opts» for a specific mapping in specific situations.

However, it is questionable whether Edelman has truly solved the explanation of the mind. His ideas are, without doubt, the complexity and flexibility of the interactions that exist in the brain as a classical system. But, in my view, the hardware described by Edelman, being classical, cannot account at the end for the holistic experience (the experience of space vision as a field of reality, or the unitary experience in proprioception, or feelings, emotions, memories, thoughts, given the holistic experience of the unit-of-conscience).

11. The neurological framework to explain reason

I will conclude my contribution to this seminar session considering in synthesis those evolutionary stages that, in my opinion, are necessary to explain the origin

and nature of reason. The theoretical assumptions that go beyond the general statement «man is his brain» are trying to explain the nature of the physical support of the brain that could make intelligible what may have occurred to produce the emergence of the phenomenological properties of the psyche and of reason. It may be speculation, but such a speculation is legitimate in science as it is based on empirical evidence. Everybody is free, however, not to speculate or at least to make other speculations (which are always inevitable in science).

a) Sensation has emerged because we attribute to the ontology of physical reality (which ultimately comes from the *big bang*) the aptness to produce «sensation». This property should be taken as a factual assumption of science that we cannot explain (we cannot give reasons to explain the fact that «matter» is «sensitive» because it could have happened that it was not, and then there would be no sensitive beings and we all would be only «robots»).

b) Life (the first cell) probably began as an organization of traditional systems of interaction (amino acids, DNA, membrane, etc.) Relations among the entities of these systems do not satisfy the properties of the primordial matter or of quantum states. Living organisms, including man, are for the most part classical systems that guarantee determinism, stability and inheritance of the species. Determinism is essential for life.

c) We think that at some point in cellular evolution a systemic property emerged which founded the production of cellular (organic) «sensation» (a diffuse «primitive sensation», of course without a «psychic subject»). To explain how and why sensation could occur, the most likely tenet is defended by the Von Neumann-Stapp hypothesis: inside the biophysical structure of organisms a quantum structure interaction emerged, but immersed in the classical structure of the cell. If the Hameroff-Penrose hypothesis were correct, the quantum network of living beings could have emerged through the microtubules of the cell cytoskeleton. Perhaps the organizational and functional structure of the quantum system emerged in living beings (evolved from an initial cellular emergence). It is probable that this quantum living structure may still be completely unknown.

d) The capacity to sense has become a tool for optimal reception (sensation, stimulus) of the information on the status of internal and external environment and to produce adaptive responses. The evolution produced neural mechanisms for the coordination of stimulus-response patterns and, already in complex organisms, the emergence of the «psychic subject». Animals progress in their repertoire of «signs» and «automatic response programs». We are speaking about different designs for a real way of being as «sensitive automata».

e) Every learning process, or stimulus-response connection, is already a primitive memory mechanism. However, in higher animals, with increasing brain connections, mainly in the temporal cortex, there are new features emerging in memory. According to Edelman, we believe that memory processes are the basis for reconstructing the nature and emergence of reason. Animals connect real-time experience with past records, updating the past in the present (the «remembered present» of Edelman). This new capacity born in the animal mind allows a process

of «representation» which, in principle, responds to «representative packages» formed by combining images. For example, a dog sees his «master» as a complex package of combined and intermodal sensitive records connected by a complex system of entries and reentries.

f) Relying on these representative packages based in memory, higher animals develop processes of categorization, abstraction, imagination, knowledge, language and future anticipation. Animals have even developed a primitive symbolism (a sound, a smell or a symbolic image, for example, are for a dog symbol of the complex representative package of «its master»). Its behavior responds to this complex world. In my view, therefore, pure abstraction, language, or symbolism, for example, cannot describe sufficiently what is specifically human. To do this we must specify the form of abstraction, symbolization and particular language of the human species.

g) The complexity of the animal mind, as it has been studied in ethological research in higher animals, leads to a state of psychic hypercomplexity no longer compatible with the automatic and deterministic pattern of stimulus/response. In this way, some behaviors can be observed as the ones that Konrad Lorenz and Irenäus Eibl-Eibesfeld have called «protohuman behaviors». Among these, primitive logic functions emerge and also a new «deliberative activity», characteristic of higher animals. It is a progressive «break of automatism» and an evolutionarily advance of future human reason.

h) Now, what kind of facts or processes has caused that the «animal mind» became a «human mind»? It must have probably been a continuing process which involved thousands of years. Let's first say that this development would not have been possible if the mind of hominids were not already a hypercomplex mind, as we have referred above. Probably a variety of natural and evolutionary factors have contributed to the emergence of reason. Professor Mora refers, for example, to Krantz and Fialkowski's theories. The hunting behavior and the upright position could have caused an increase in the capacity of «persistent attention». This may have contributed to the humanization. There are other theories that describe new factors that could also have contributed to humanization: Gehlen's loss of specialization, the role of working in accordance with Luria (Marxism), socialization / language (Thobias, R. Leakey, Eccles), nutrition (Faustino Cordon), protohuman behaviors (Lorenz) or the biology of cognition (R. Riedl). All these theories are speculative; they are not final scientific evidence, although they have in their favor serious empirical evidence. However, they are «hypothetical-theoretical constructs» that are part of science with epistemological legitimacy.

i) The above theories are not mutually contradictory and can be accepted as complementary. No doubt the humanization was caused by a number of contributing factors (for a system-of-causes). However, in my opinion, I do not know of a more explanatory hypothesis than that proposed by Xavier Zubiri. Zubiri's theory hypothesizes that the human species – as opposed to formalization of the animal senses and the objectification of animal behavior – could have

developed a neurological hyperformalization that would have made possible to «sense» things (stimulus) in a new way. This way is qualified by Zubiri as «sense of reality». This contemplative attention would qualify humans to look at things, to be interested in the things themselves, looking at them in a new way. Animals live distracted, attentive only to the «signals» that arise learned automatisms. The human animal (animal-of-reality) would look at the world being interested in its content. Zubiri's second hypothesis to explain the emergence of reason depends on the «sense of reality»: man would be able to understand (realize) that the real things «are real as structures». So what things profoundly are (essence) is said by Zubiri to be substantive systems (systems of physical features organized in systems or structures). Therefore, and this is the third scenario (hypothesis), he would consider the human species to survive in the environment in accordance with the representation of reality that they build in their mind. The human mind works as structural analysis of reality and human representations contain the result of a process of specific structural analysis and synthesis. Science, for example, is a complex analysis and synthesis of structural representations of the world that respond perfectly to the nature of reason in this sense.

j) In addition, Zubiri's theory – which we believe is a more accurate and comprehensive proposal of ideas consistent with Poli's statements at the first session of the seminar – not only affirms that the hyperformalized man «senses reality» «like structure». It also tells us that the «sense of reality» occurs in a «field of reality» and in this way connects Walach's ideas concerning the principle of complementarity applied to psychology.

k) Finally, we can relate all this with what was stated above on the animal mind. Animals have processes of representation, categorization, abstraction, imagination, knowledge, language, symbolism and so on. But human beings differ from animals because they provide a new content to these processes: the representation of things as real and their structural idea of the world and of the real processes. Reason is the human representation in that specific level of «structural representation of reality». Representation, abstraction, symbolism, language, imagination, and other mental processes, they are «human» because they are «rational», because they include the evolutionary new emotional reason of the hyperformalized man.

l) The conjecture is thus that the human mind could emerge because animals already had a mind with highly complex processes. For example, the representation of reality can be concrete (an object) but may also be an abstraction (the reality as such). It seems then that we must assume that this abstract exercise took place in the animal mind and it allowed the human mind to build the more complex representation of reality as such. It also allowed the transit of reason towards the construction of formal sciences. The 'formal' is something imagined by man, but the act of imagination is based on an *a posteriori* experience of reality and a representation of the world as a structure. This is what was discussed with Gregor Nickel in the second session of the seminar.

V. CONCLUSION TO SESSION IV

It is clear that the fourth session of the seminar has provided an essential approach for explaining the origin and nature of reason: reason is a product of the brain and of the nervous system. Therefore, if life does systems analysis (Poli), it is because it has a nervous system. If we are able to produce formal sciences, it is because the brain can produce them (Nickel). If the psychological experience may be understood in the sense of a psychological principle of complementarity, it is because the brain constructs an experience of different objects in space-time and also because it builds the holistic experience of reality (Walach). If the functional explanation of reason, as it is described in an epistemological analysis, must be attributed to evolution (an evolutionary explanation), it is because the evolution of the brain has enabled the various stages in the animal and human mind (Curado). The fourth session of the seminar raised a number of additional ideas that can be summarized as follows. The substantive issue has been how and why the brain produces the nature of mind and in humans the functional nature of reason.

1) Professor Francisco Mora has established the foundations to understand brain evolution in natural history. First, the growth of brain weight, as allometric component (the ratio between body weight and brain) and the absolute component (weight growth at all). Second, Mora referred to the change in brain organization and variant location of its functions. Third, the qualitative change in neuronal formations, their new morphology and dipole in the two dendrites. These changes, which occurred at different moments in the evolution of the genus Homo, were essential for the emergence of human behavior and reason; abstraction, language and symbolism marking the boundary of the appearance of reason.
2) Professor Camilo José Cela Conde has examined the classical thesis that behavior depends on the specific human brain functional states. We know that there are correlations between brain activity and mental functions, as given in our subjective experience. Little is known besides the pure observation of the correlations. However, they let us know that the psychic world has been produced by brain evolution through the stages of the genus Homo, along the lines of Professor Mora. The modern techniques of magneto-encephalography make it possible to observe these correlations in characteristic features of the humans, as are the moral judgments and aesthetic preferences.
3) In addition, Professor Javier Monserrat has referred to some additional aspects of the necessary connection of neurology with physics, physical models applied to the interpretation of the brain, the explanation of the origin of representation processes based in memory in the animal mind, the distinction between the animal and the human mind, and the need to specify what is distinctively human in the process of representation, abstraction and symbolism.