

# THE NEUROBIOLOGY OF VISUAL ARTS – IMPLICATIONS IN THE NEUROPLASTICITY PROCESS

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## ABSTRACT

Recent studies in neurosciences have opened a new perspective in understanding the visual art phenomenon. The functional neuroimaging methods have highlighted the cerebral areas involved in the perception and creation processes. This had led, in 2000, to the emergence of frontier domains, amongst which we find the neuroaesthetics. The study of mechanisms involved in neuroplasticity and neurogeneration has led to hypotheses related to the influence of the environment on the development of the brain.

## INTRODUCTION

The evolution of art and the constant search for new means of artistic expression meet the rapid technological development so that alliances appear in the convergence area, alliances that, at a first glance, may seem unusual, but that in fact contribute to innovation. Such an example is the frontier domain of neuroaesthetics which appeared, on one hand due to the endeavours of the artists to comprehend the perception phenomena and to employ them, and, on the other hand, due to the preoccupations of the neuroscience researchers to study the neurobiological substratum of the perception process. Neurosciences have proven their relevance in aesthetics by following different paths; first and foremost have identified the neural mechanism, which constitutes the substratum of the aesthetic activity for the creative artist as well as for the art receptor.

## WHAT ART IS AND WHAT ART DOES

Although today's theoreticians have broadened the perspective with respect to what needs to be in-

cluded in the concept of art, the academic theory denies, in general, the existence of generic principles that are the foundation of creation and art appreciation. Nevertheless, the observation of the evolution of artistic phenomena suggests that art is inherent in human nature and apt to adjust throughout the journey of social evolution. To list only a few arguments: 1) art is present in any culture that is or was known, 2) in all traditional societies individuals or groups of individuals had devoted time, energy and material resources to the arts, so much more than can be explained by evoking a 'non-productive' activity, 3) from the very first moments of life, the child is predisposed to appreciate and engage in artistic activities, 4) art treats subjects which are important to human nature.

In the last decade, the evolutionist psychology and neurosciences have launched hypotheses on nature and the functions of art.

## FUNDAMENTAL NOTIONS ON THE PHILOSOPHY OF ART

The word *aesthetics* has its origin in old Greek, where *aestheta* meant things perceived through

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senses, in opposition to *noeta* signifying things thought or things immaterial. Aesthetic is an adjective, while Aesthetics is a research domain preoccupied with the aesthetic experience and aesthetic properties. This domain had received its name when appropriated by Alexander Baumgarten in his book “Aesthetica” (1750 / 1758) ‘Things known are to be known as [...] the object of logic; things perceived are to be known [...] as the object of the science of perception, or aesthetic’. (1) The idea of aesthetics as a science did not grow roots, but the term had begun to designate the contemplation and appreciation of an object (not necessarily an object of art) via perception. On the other hand the term ‘Aesthetics’ had also become synonymous with a philosophical field of study devoted to theoretical inquiry into art and aesthetic experience.

In order to affirm the necessary and sufficient conditions enabling art to exist, we must establish what characteristics in an object allow it to be considered art, what characteristics permit the affiliation to the artistic domain. The question, in reality, resides in what can indeed be considered art. There are two fundamental issues that Aesthetics deal with – the essential nature of art and its societal significance.

We can identify 3 elements that epitomise the research domain of philosophical Aesthetics: the first refers to the *practice* of art or to the creation and art appreciation activities, the second refers to certain properties of objects — so called *aesthetic properties* such as beauty, grace and dynamism; the third implies a certain type of *attitude, perception, experience*, which can also be labelled as aesthetic. However, in order to explain what art *is*, we must define what is its *value*, what makes art valuable. In order to achieve this, we must show that there are four values in relation to which we can discuss on a new normative theory of art: *pleasure, beauty, emotion and knowledge* and are necessary and sufficient to define an artistic object.

### NEUROAESTHETICS – A REVIEW OF THE EVOLUTIONIST AND NEUROCOGNITIVE HYPOTHESES

The theories pertaining to the philosophy of art have connected intuitively the justification of certain phenomena related to appreciation and artistic creation to certain inherent emotional and mental abilities and could not shy away from explaining the artistic phenomena by means of intrinsic functions of the brain. When asking the question ‘what

is art and what it does’ the evolutionist psychology and neurocognitive sciences endeavour to offer new answers.

*The evolutionist psychology* agrees that the final function of any adaptive behaviour is to favour the survival of the individual and the success of their reproduction, what is called *fitness*. The manifestations and processes that sustain this phenomenon are not self-evident and the individuals rarely acknowledge the final motivation behind immediate actions and motivations due to the fact that they behave and respond the way they do. (2)

*The neurocognitive approach* of the function of art relates, generally, to the visual arts and brain, and, even though it does not openly suggest a perspective based on adaptation, it suggests that by studying thoroughly the subjects related to the brain in general and to the visual processes in particular, an aesthetic theory based on biology can be developed.

As human beings, our simple interaction with the world around us is done under a constant state of aesthetic evaluation. We engage in a dialogue with reality through our senses, by perceiving external stimuli and awarding values (whether aware or not) for each entry, though a mechanism based on gratification. By using neuroimaging technologies, scientists have begun to understand the processes occurring in the human brain when in contact with and in the process of creation of art. This study, known as *neuroaesthetics*, throws a new light on the values ascribed throughout the centuries to the artistic phenomena, on their dissemination and raises questions in relation to the nature and future of art. Semir Zeki, leader of the Neuroaesthetics Institute in London, is considered to be the founder of this domain and is the one presiding over the International Neuroaesthetics Conference which takes place at the Berkley University each year. (3)

The neuroaesthetics assessment excludes from the discussion the arguments related to ‘style’ and does not desire the review of the theories on artistic production from ancient times to present day. The objective is that of understanding rational criteria of aesthetic perception on the basis of neurosciences and biology.

Present day knowledge on aesthetic perception explains the aesthetic phenomena in terms of mental mechanisms and gratifications and establishes the relationship between these and certain natural laws. In his activity as a neurologist, centred essentially on the exploration of cerebral mechanisms involved in the visual processes, Semir Zeki has opened a new field of study, which combine em-

pirical aesthetics, art and neurosciences. Zeki identified employing functional magnetic resonance imaging (fMRI) those areas in the brain activated by the process of aesthetic evaluation. For Zeki, art's function is to search for permanent, essential and characteristic properties of objects, surfaces, faces and situations and, thus, obtaining a more profound understanding. (4) Similarly, Ramachandran and Hirstein contemplate art, with reference to visual art, employing certain techniques such as emphasis, deformation and caricature of reality, thus conditioning the viewer to efficiently resolve perceptive and cognitive problems, therefore being an intrinsic property of the brain, having as purpose the increase in efficiency when coming face to face with complex survival situations. (5)

### NEUROAESTHETIC ARGUMENTS TO SUPPORT AESTHETIC THEORIES

Aesthetic theories in philosophy support the existence of four values that define a phenomenon as being artistic and transform it in object of aesthetic appreciation: **pleasure, beauty, emotion and knowledge**. Further we shall see how these can be associated with scientific explanations that neuroaesthetics put forward.

The optical apparatus has the Darwinian function to gather information about the world around in order to ensure survival and this is achieved by selecting the essential properties of encountered objects, firstly removing the information lacking relevance, then comparing the selected information with past experiences. To make this task possible, it must generalise the visual event, or, as Zeki affirms, 'the brain is interested in obtaining *knowledge* about those permanent, essential or characteristic properties of objects and surfaces that allows it to categorise them. (6) On this basis, Zeki defines the purpose of art as an evolutionary product of this selection process. From this perspective, visual arts are 'an extension of the major function of the visual brain' and the special role of the artist from this point of view is to exploit 'the characteristics of the parallel processing- perceptual systems of the brain'. (7)

Art had been produced and assessed by each culture and society from the beginning of time; it is a constant of human experience. Scientists have now begun to understand man's predisposition to interact with artistic phenomena and have demonstrated that the human tendency to appreciate external stimuli through aesthetic judgements has its

roots in the evolution of prefrontal cortex. (8) The mechanisms activated in aesthetic appreciation, localised in this region of the brain are those activated in the survival mechanisms, 'guiding us towards what we need to survive [...] and warning us to avoid peril.' (9) For instance, when we observe the aesthetic characteristics of a tiger, the vibrant colours and texture catch our eyes, signalling the necessity to proceed with caution. This theory is transferable to our perception of art. We evaluate beauty in art with the same instruments as the prefrontal cortex with which we evaluated the tiger, although, no doubt, the sense of evaluation differs'. (10)

A natural extension of this evolutionist theory is the study regarding the reward mechanisms of the brain. Ann Marie Barry, professor in communication said that, "what all aesthetic theories seem to have in common is the idea that pleasure from images (of whatever kind) is gained through the senses and leads to a feeling of euphoria'. (11) Aesthetic appreciation produces a feeling of satisfaction as a result of a number of cognitive processes. Barry proposes 'the achievement of visual meaning from visual inputs results in aesthetic pleasure simply for the sake of problem solving alone as everything comes together in a unified concept'. (12) Neurologists V.S. Ramachandran and William Hirstein follow the same line of thought, deciphering, in their article "The Science of Art", some of the processes that are the foundation of artistic pleasure. They argue that the brain's ability to overcome confusion (in the sense of the inability to understand), through grouping and perceptive association in the process of contemplating art works, with reference to the plastic arts, and abstract painting in particular, has as result the *rewarding sensation*. (13) This cerebral mechanism that leads to the rewarding sensation that accompanies aesthetic judgements offers proof that the visual system is directly linked to the limbic system, the place where *emotions* are formed. Due to this connection, 'we are inclined to make associations that engage other clusters of neurons because whole networks are activated when parts are tapped we are inclined to make associations'. (14) These 'other neural groups' may include cerebral areas involved in memory, thus introducing subjectivity in the aesthetic appreciation. Individual experiences and memories, together with the associated emotions will form a personal artistic perception. Nevertheless, although the artistic assessment is a personal, subjective phenomenon, there are certain *aesthetic perception patterns*. Amongst them there are symmetry and

the golden ratio (1:1,618) which are generally considered more pleasurable if the rules are missing. (15)

After the brain evaluates the aesthetic object through the rewarding mechanism, the result of the aesthetic judgement, similar to the majority of the neural pathways is subject to a series of recurrent loops. These loops tie the various areas of the brain, each informing the other, indenting to finalise the aesthetic experience. Neurologist Luca Francesco Ticini, with the Italian Neuroaesthetic Society offers an example to explain this phenomenon: “external factors (for example, those socio-cultural) may lead to an inhibition of the frontal lobes, making us less impartial in our aesthetic judgements. If we were to demonstrate that the influence of socio-cultural factors may deactivate the activity in the frontal lobes and thus modifying the aesthetic judgement, we would re-evaluate more positively a work of art which we do not appreciate when it is placed in a familiar context (i.e. when we realise who the artist is and that they are well-known and appreciated) (16) This way, areas of the brain outside the prefrontal cortex influence the way we appreciate a work of art. It appears to be true that aesthetic appreciation is a function of multiple interconnected cerebral systems and not a result of a unique visual process.

### NEUROBIOLOGICAL SUBSTRATE IN THE EVOLUTION OF ART (17)

From the point of view of what we can call aesthetic neurobiology, the brain is composed of two repertoires, a primary repertoire, the volume of the brain we acquire at birth and a secondary repertoire consisting in a process that enables the primary repertoire to be sculpted and transformed in patterns and maps aided by millions of sensations resulted from the stimulation generated by the information received by our senses. In this context, we can discuss neuroplasticity as a brain modelling biological process. Ingredients are the sensations that are formed when there is contact with the outside world and with the spatial-temporal relationships existing between them. The transforming brain adapts to the new spatial-temporal relationships as the neurons and the neural networks add new information to a process called *neural Darwinism* (18), an evolutionary theory applied to neurobiology, arguing that neurons that most easily adapt to the new configuration survive and show exuberant growth. There is a reconfiguration and a

displacement of neurons and of neural networks that are not used, therefore stimulated. In other words, there is a continuous reconfiguration of the brain based on strengthening and developing as a consequence of stimulation and weakening and death as a result of lack of stimulation. We understand in this context the key role of stimulation.

The great scientist Ramon Y Cajal (19) (1852-1934) wrote: “In adult centres the nerve paths are something fixed, ended, immutable. Everything may die, nothing may be regenerated.” (20)

Recently, this dogma has been overturned with clear evidence of neuroplasticity and neuroregeneration. The interneuronal connections can be improved or deteriorated, depending on experience and, in certain cerebral areas, through physical interaction with the environment, even the total number of neurons can change. These changes in the cerebral structure, to external stimuli, reach the highest point during the embryonic period, but recent data indicate that they continue throughout adult life. Research has demonstrated the existence of the process of “neurogenesis”, namely the generation of new neurons that occurs in the adult brain in certain cerebral areas called “germinal niches”, such as the subgranular zone of the hippocampal dentate gyrus and the subventricular zone of the lateral ventricles. Neural stem cells present at this level, under the influence of certain stimuli, can divide symmetrically into identical neural stem cells or divide asymmetrically into a stem cell and a neural precursor cell. Neural precursor cells formed here have the capacity to develop into fully functional neurons. It has been shown that neurogenesis is influenced by the manner we interact with the environment and, implicitly, by the interaction with the visual arts.

### THE IMPLICATIONS OF AESTHETICAL PERCEPTION UPON THE ARTISTIC CREATION

Now that we have achieved a basic understanding of the brain’s mechanism of aesthetic perception it is necessary to discuss its implications, specifically those relating to the art world. First and foremost, the patterns across all human aesthetic perception allow art to be a means of communication. Ticini says “this common basis, (we have when we place ourselves) before art, puts us on the same interpretive plane, allowing us to communicate – through art – profound impressions and emotions, which at times we would be unable to express in words” (21) Ann Marie Barry echoes Ticini and

takes his argument a step further, declaring, “*shared process, rather than shared experience, allows for communication and expanded understanding in both artist and perceiver. Because the neural circuitry by which the brain works is a common ground shared by all people, artists can manipulate neural structures to achieve desired effects, and these effects can then become... the formula of a particular emotion*”. (22)

In this context, the Zeki’s idea resembles to idea of *Einfühlung – empathy* (23), as explanation to this phenomenon. He defines it as a link between the “pre-existent” forms within the individual and the forms in the outside the world which are reflected back. (24) The pre-existing forms are formal predilections of the human brain, as they have evolved along with the biological properties. The implications of this fact are found on three levels.

*The first implication* refers to the fact that we approach any act of perception through a visual stock of forms and colors formed throughout the individual life. This stock becomes a model (pattern) that interferes with new perceptions and affects the manner in which we receive new images. Zeki finds visual records similar to the Platonic ideas, in the same way that Gestalt psychology was talking about good form or about perceptual tendencies.

*The second implication* of pre-existing forms regards those specialised cells (selective) which are active only in connection with certain colours, lines and forms. Zeki performs an analysis on Mondrian’s painting and deems that the limitation of the artistic language by only using horizontal and vertical lines and a restraint number of primary colours is an “attempt to put on canvas the constant elements of all forms” and is therefore an “effort to reduce the complexity of all forms to their essential value or in neurological terms, to find out the essence of forms as it is represented by the brain.” (25)

*The third implication* suggested by Zeki is the entire field of proportions and geometry. The idea of privileged harmonic relationships has accompanied the artistic and architectural thinking ever since the Renaissance.

Semir Zeki said that: “artists are, in a sense, scientists in the field of neuroscience, exploring the potential and capabilities of the brain, although by using other methods.” (26) Ramachandran shows that the answer to the question whether mimicking the physiological processes in the human brain should be pleasant for the body is given by the evolutionary biology. From this point of view, Morse

Peckham said that: “art is like a general rehearsal for a real event, when it is vital for our body to be able to support the cognitive tension... art gives us the opportunity to strengthen our capacity to overcome the disorientation in front of real and significant problems.” (27)

When the neuroaesthetics appeared as a field of investigation, it was not expected for it to provide a complete theory of art, but to make certain predictions of some specific empirical demonstrations, to bring together evidence from disciplines as neurophysiology, ethology, perceptual psychology and evolutionary biology and to stimulate a lively debate, as demonstrated by the huge number of comments received. The responses have been contradictory: psychologists and neurologists has reactions largely positive and enthusiastic, while artists and critics manifested from interest and challenge to outrage.

## CRITICISMS AND CONTRA-ARGUMENTS

One of the most common criticisms that raises questions even the foundation of the neuroaesthetics, is that it provides a restrictive perspective which minimises the value of art. Ramachandran answers to these charges by bringing three arguments: the first – that reductionism is the strongest strategy known in science, the second – even if the explanations are reductionist, Ramachandran repeatedly emphasizes the need for two other levels: the functional level or the computational logic (argued by Marr, Pinker, Tooby and Cosmides or Wilson) and the evolutionary level and the third argument – the attempt to understand the basic processes that support the phenomenon does not eliminate the phenomenon, in only explains it. As far as the spiritual value of art is concerned, Ramachandran argues that the explanation of the phenomenon does not lead to any decrease nor to any cancellation of its value. Furthermore, by confounding the methods used to assess the physiological substrate of the effect of certain processes with the value of the process calls into question the value of theoretical discourse of those making these criticisms. (28)

Another potential objection to this analysis may be that originality is the essence of artistic creation and that previous analysis does not capture it. This objection overlooks the fundamental difference between artistic and scientific approaches, because art deals with features and is based on a variety of particular phenomena, while science deals with the general that supports features, namely with the general phenomena that support originality. In addi-

tion, an analogy with the analysis of language made by the American linguist Avram Chomsky shows that “deep structures” discovered by Chomsky have enriched our ability to understand language even if it does not explain Shakespeare, Dostoevsky, etc. Similarly, this type of research can help in setting

up a framework for understanding aspects in relation to visual perception and aesthetic experience, although the topics regarding the originality and individuality of architectural processes would not be reached.

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