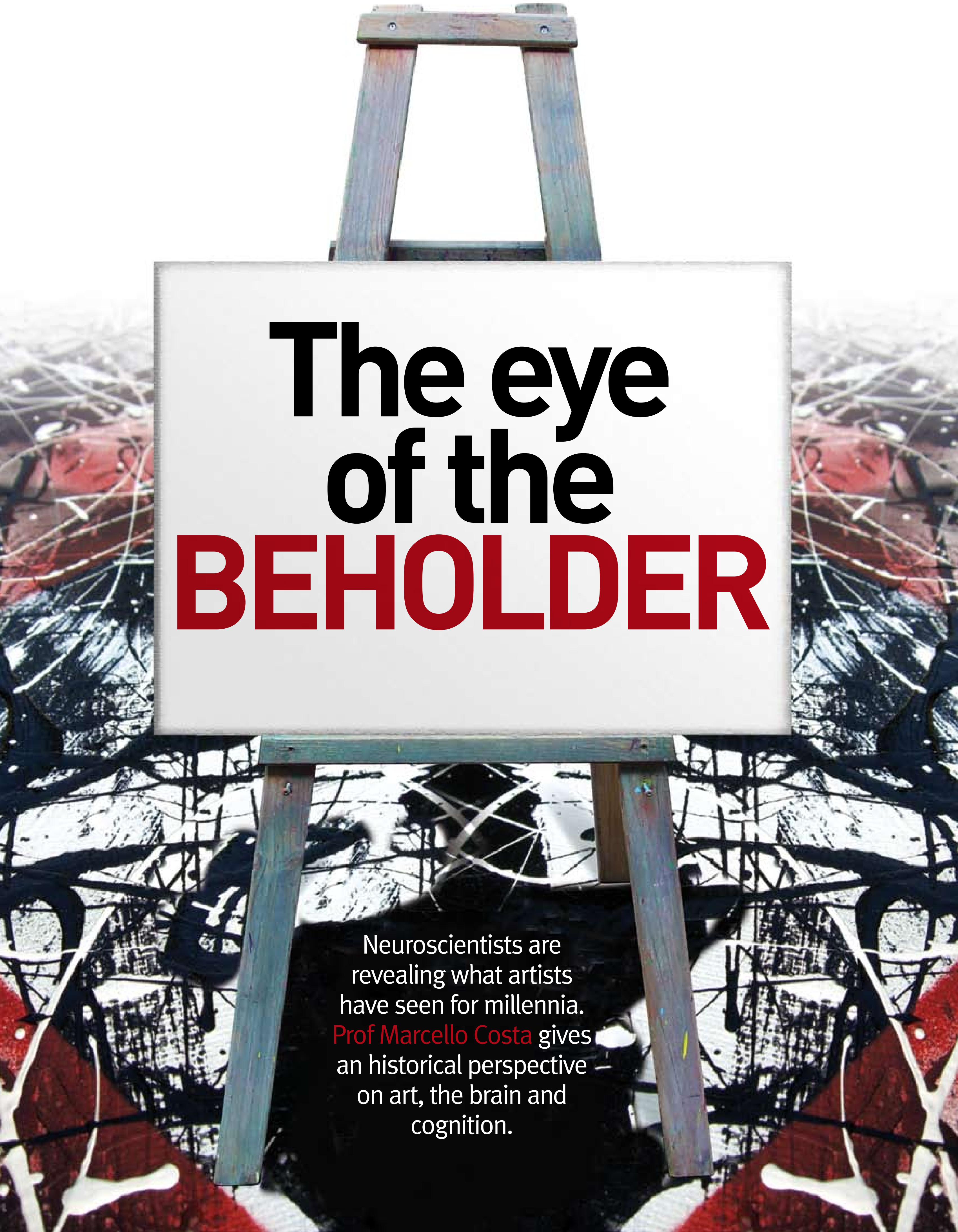

The eye of the BEHOLDER

Neuroscientists are revealing what artists have seen for millennia. Prof Marcello Costa gives an historical perspective – on art, the brain and cognition.

WHAT IS ART? WHAT IS beauty? These are two questions that keep arising into the broader arena, not just in the Philosophy of Aesthetics circles.

In this article I will present the view that art is part of human endeavor, linked to the development of knowledge of the world and ourselves. Thus the distinction between artistic and scientific activities is more due to historical accidents than to irreconcilable differences. This approach may solve some of the apparent discrepancies between these all too human activities.

The idea that perhaps the very human desire to create art comes from some evolutionary advantages has spurred several neuroscientists to search for brain-based explanations why humans express themselves through "art". Semir Zeki, who heads the neurobiology laboratory at University College London, and is director of the first Institute of Neuroesthetics, claims that great art can be defined in neuroscientific terms and that aesthetic theories will only become intelligible and profound once based on the workings of the brain (Zeki, 1993, 1999). Vilayanur Ramachandran, director of the Center for Brain and Cognition at the University of California, San Diego, claims to have identified several neuronal principles underlying artistic work (1999, 2005).

The general argument shared by neuroscientists goes something like this: we experience our visual perception as images, which are not simply received passively by the brain. Visual perception is due to an active participation of the brain, which constructs images by a complex set of steps, utilising many parts of the brain. It does so in real time and the ability to perceive certain aspects of the external world has evolved over a long period and involves certain "rules" that were more suitable for survival than others. Such rules may well coincide with the "preferred" way of seeing the world in terms of proportions, colour, balance and harmony, all generating a subjective feeling of pleasure and eventually beauty. (A superb treatise of how "beauty" evolved in recent cultures can be found in Umberto Eco's recent book; 2006).

According to neuroscientists, this aesthetic experience is well embedded in the neural circuits that underlie our perception processes. In other words, they say that perhaps there is a "deep structure" or a "universal rule" underlying all artistic experience. It follows that in studying the way in which the brain prefers certain images, neuroscientists will also clarify what are the bases of aesthetics itself; that is to say, what are the neural bases of artistic experiences.

This view really dates back to the visual physiologists in the 1800s. From a lecture given by Hermann von Helmholtz in 1871 (quoted in the John Hyman paper on "Art and Neuroscience"): "We must look upon artists as persons whose observation of sensuous impressions is particularly vivid and accurate, and whose memory for these images is particularly true. That which long tradition has handed down to the men [sic] most gifted in this respect, and that which they have found by innumerable experiments in the most varied directions, as regards means and methods of representation, forms a series of important and significant facts, which the physiologist, who has here to learn from the artist, cannot afford to neglect. The study of works of art will throw great light on the question as to which elements and relations of our visual impressions are most predominant in determining our conception of what is seen, and what others are of less importance. As far as lies within his power, the artist will seek to foster the former at the cost of the latter."

Other non-neuroscientists appear less convinced that the bases of art or aesthetics could be found on a bunch of neuronal circuits. John Hyman, a philosopher from Oxford, in his most recent writings (2006), criticises both the interpretation by Zeki and Ramachandran, mounting methodological arguments against any neuro-aesthetic projects. Nevertheless the search for neuroscientific bases of artistic experiences is at its infancy and will surely continue opening new perspectives on the long history of human artistic activities.

Art versus science?

Is there any relation between the way in which the brain constructs experiences for aesthetic pleasure, and understanding the world itself? There are good reasons to agree with this view, as both activities are dependent on similar brain functions and that both have evolved in parallel, suggesting that perhaps they both sub-serve important adaptive functions for the human species. Therefore there is a case to be made for art and science to be treated in parallel.

Yet since the publication of the short but influential book of "the two cultures" by CP Snow, mutual suspicion between artists and scientists about the nature of their activity has not abated. Science and art are often regarded as two completely different and irreconcilable modes of being in the world, although for many there is a genuine desire to bridge the apparently insurmountable gap. After all E.H. Gombrich wrote "To the historian of art, it is evident that the authors' notion of 'art' is of very recent date, and not shared by everybody."

When Homo Sapiens appeared in Africa around 200,000 years ago it appears that she (standing for she or he through this article) had not yet developed the ability to express herself with symbols and drawings. The story of human cognition jumped ahead when humans could depict, by manual actions, some

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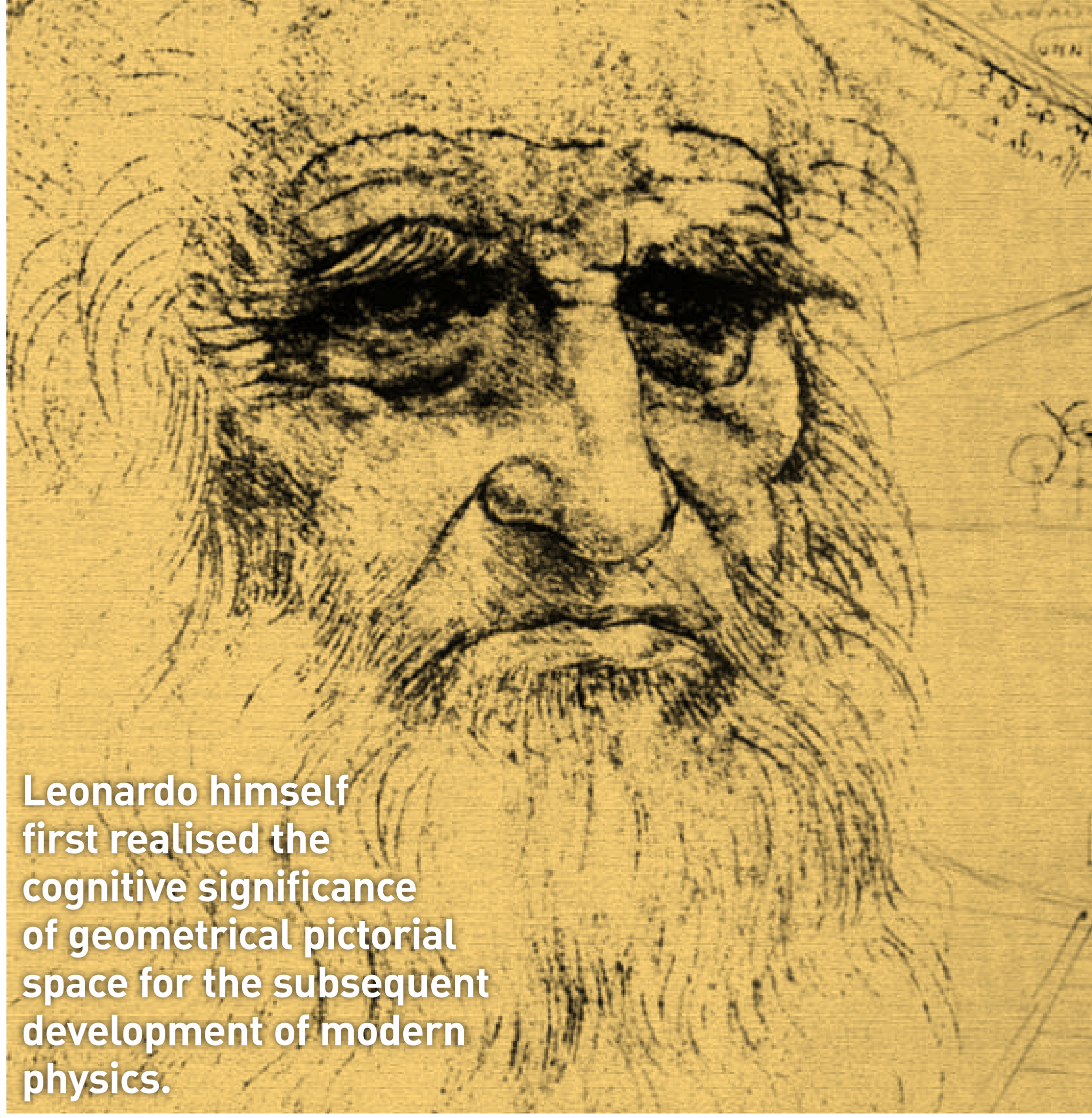
aspect of visual experience onto a surface. This places drawing and painting straight in the very first step in the development of explicit knowledge, a hallmark of science. The history of pictorial representation should be seen thus as part of the development of knowledge of the world. No one would dispute that the nature of knowledge has become a fruitful field of neuroscience (cognitive neuroscience). Similarly it is not surprising that neuroscientists involved in understanding how the brain generates knowledge, including its perception of the world, have become interested in how the brain generates artistic work (neuro-aesthetics).

In this story two intersecting aspects will appear. The first is the pictorial representation of the external world, as a direct process of knowing what is out there. The second is a pictorial representation of the very way in which the subject sees the world - a kind of pre-neuroscience exploration. Both aspects are based on vision, which is fundamentally a process to establish where things are in space, how they appear (ie shape and colour), and eventually what these things do, ie the visual sense of movement.

Depicting the world

The appearance of prehistoric drawings and paintings signal the emergence of a form of visual communication, an explicit form of sharing of experiences and information. The history of pictorial representation is thus part of the history of how brains of several people construct together a common "reality" that goes beyond the individual experience. This path can be recognised through several steps. The first probably is the outlining of objects and animals on surfaces in Paleolithic art. From this initial step in the ability to separate a particular bit of the visual world from the "background", around 40 to 50 thousand years ago, probably developed much later into the more abstract signs of written language (five to six thousand years ago). The process of outlining visual images becomes well developed in the Egyptian and Greek-Minoan cultures, with human images shown as profiles. Only in the sixth century BC did initial drawings of faces from an oblique angle begin to appear on Greek vases. This was the beginning of the golden period of Greek-Roman realism as it developed to its magnificence with the paintings preserved in Pompeii. The representation of figures were not only highly realistic but were also placed in a realistic space.

Realistic pictorial representation took a downturn for about a millennium during which time painting became more simplistic and more symbolic. Almost certainly with the fall of the Roman Empire and European life entering the "dark ages", the artistic skills of the late Roman period were lost – and humanity lost for a time the skills to represent objects correctly.



Toward the late mediaeval times, painting began to recover a sense of realism with artists such as Duccio da Boninsegna and Giotto, although they were not yet representing space correctly. This only really began again in the fifteenth century when Brunelleschi, an early Renaissance painter and architect in Florence, invented an optical instrument to develop the geometrical representation of space.

Geometrical perspective was thus born and Leon Battista Alberti, a painter, architect and also writer, wrote his famous treatise on perspective (De prospectiva pingendi). With painters such as Masolino da Panicale, Piero della Francesca and Leonardo da Vinci, space representation and people and objects within it were portrayed with precision and to perfection. With the school of Piero della Francesca's painting of the famous "Ideal City", the mastering of pictorial space reached its peak.

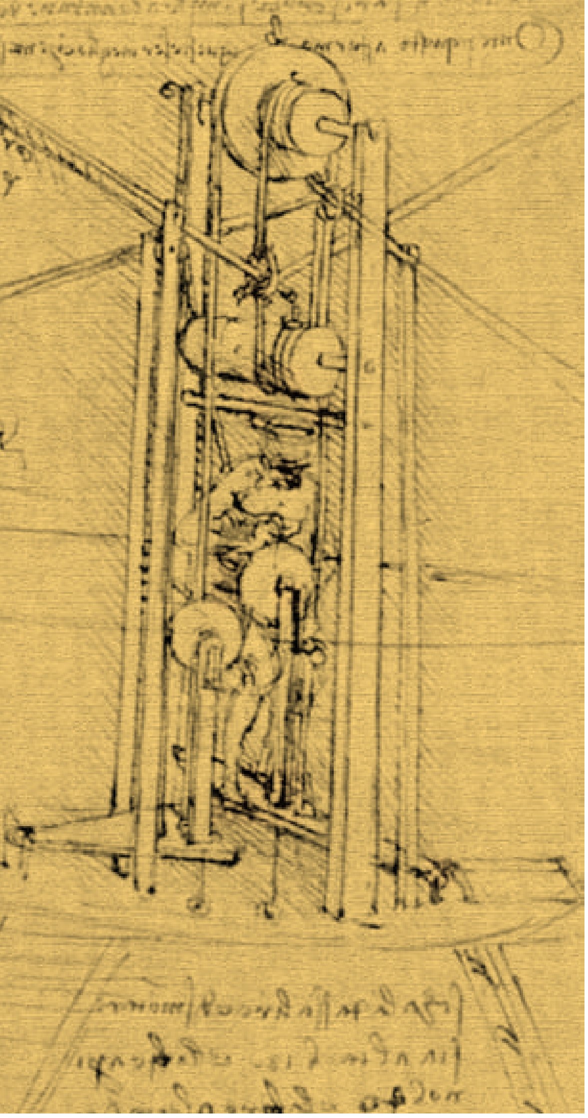
Leonardo himself first realised the cognitive significance of geometrical pictorial space for the subsequent development of modern physics. In subsequent centuries, space in paintings no longer needed lines of perspectives for the objects and persons to be in a "realistic space". The mastery of Caravaggio and Jan Vermeer shows that painting incorporated a complete realistic sense of space without having to resort to geometrical lines (for a full treatise of the history of perspective see Martin Kemp's book "The Science of Art", 1992). They conquered the representation of space and led the contemporary artist Frank Stella to state in 1986 that "after all the aim of art (pictorial) is to create space. A space that is not compromised by decorations or illustrations; space within which the artist can place its subjects."

Painting and drawing thus can be regarded as first steps in the development of knowledge of space. In doing so the artists themselves gave to these representations a geometrical dimension, potentially quantifiable and thus a precursor of modern science.

It is interesting that in the Florence of the early Renaissance, the use of quantitative proportions was in use for everyday life activities. Geometrical quantification of regular and irregular bodies including the human body was common amongst painters such as Albert Durer, Piero della Francesca, Leonardo da Vinci and others. Galileo Galilei, often portrayed as the initiator of modern science with his idea that the world is written in geometrical language, also applied the techniques of painters to calculate the projections of solar spots from his telescopic observations.

Thus art and science were intertwined and were the common denominator in the quest for realistic representation of the world. It could be claimed that without the development of pictorial space, subsequent development of space in physics would not have occurred.

Yet even in the early seventeenth century, when pictorial space was perfected, the concept of potentially



infinite space was far from being acceptable. Giordano Bruno was burned in Campo de Fiori, Rome, for promulgating the very idea of infinity of space - a stark reminder that ideas in science were not always accepted by authorities. Galileo found this out for himself only a few decades later.

As a result Descartes, who came after both Bruno and Galileo, was far more cautious in engendering adverse reactions from the religious authorities. He devised a simple way to keep separate the world of "things" (res extensa), from the world of spiritual life (res cogitans), thus enabling him and thereafter all scientists to delve into the secrets of the world in a scientific way without encroaching on spiritual matters.

The price we still pay for this dualism is that scientists and non-scientists alike are still finding it difficult to deal with the "res cogitans" or "thinking stuff". But it is Descartes who unified algebra and geometry, following the development of geometrical space by artists. This in turn permitted Newton to add a time dimension, thus adding dynamics and creating the physics that permeates much of our modern life and enabled Einstein to postulate that gravity itself is actually the curvature of the geometrical space of the four dimensions we live in. Geometry, with its mind boggling topological possibilities, still represents an important approach to the study of the universe in modern theoretical physics.

In parallel with the revolution in physics going beyond the Euclidean space of three dimensions to the Einsteinian four-dimensional space, painters such as Cezanne, Picasso, Braque and others were trying to go beyond simple three-dimensional perspective, trying to represent objects seen simultaneously from multiple directions. The short-lived Cubism in the first part of the 1900s was the early answer.

With the full mastering of the means of representation of space and things within it, realistic painting had reached its limits by the early 1800s and was at risk of being replaced by photography by the end of that century. It is perhaps not by chance that painters of the 1800s started to "simplify" their brush strokes, initiating the "impressionistic" period.

The Impressionist painters realised that they only needed to hint and that the brain would do the rest, constructing a full realistic visual experience. It's as if painters such as Monet, Manet, Renoir, Degas, without realising, were exploring the way in which the brain constructs the visual image, thus preceding the initial findings of modern neuroscience. Just as Renaissance painters were pioneers in the quest for representing space, so the Impressionists can be regarded as pioneers in the search of how our brains construct a realistic world. Although painters may not always have seen themselves as investigators, many including Kandinsky, sought to reveal the hidden rules of aesthetics for which neuroscientists are now searching.

Neuroscience over the past decades has begun to throw light on the processes of visual experience. The process of vision involves many different parts of the brain each with remarkable complexities and features. The simple recognition of objects requires the visual cortex to transform the otherwise confusing bombardment of colour, shape changes and movements into a simple outline of objects. The brain draws this recognition as a kind of map of neural activity in the visual cortex, reproducing the very contours of the perceived object. This is perhaps what the early Palaeolithic cave painters enacted (Lewis-Mithen, 1996; Solso, 2003; Williams, 2002).

Some of the abstract painting of the twentieth century gives a hint of the possibility that modern painters realised, without being neuroscientists, that their brain decomposes images into separate elements (Gregory et al 1995; Zeki, 1993). Piet Mondrian's remarkable rendition of a tree ("The Red Tree", 1908) followed by other paintings that appear as in an abstracting sequence, first as an Impressionist tree, then with more and more abstract versions, ending eventually with a set of separate short lines on a canvas, still very pleasing to the eye (eg "Pier and Ocean", 1915).

Interestingly, short lines are what the visual system first extracts from a visual field. Specific nerve cells in the visual cortex respond specifically to short lines of different orientations. Hubel and Wiesel, the two neuroscientists who discovered this feature of our brain, gained the Nobel Prize for this in 1981. An outline of an object is made of several such lines, corresponding to specific cells in the brain. The ability of painters such as Seurat (eg "The White and the Black", 1881), to enhance contrast between object and background even without using lines, reflects the ability of the visual system to create the "illusion" of an exaggerated contrast.

It has been said often that a work of art is not a true mirror image of the world. The meaning of such a statement becomes clear when seen in a neuroscientific perspective of the brain processing visual images, and not simply "copying" them from the external world. The choice of some modern painters to use just colours producing stark canvasses (eg Henry Matisse, "The Red Studio", 1911), is well reflected in the discoveries by visual scientists that a specific part of the cortex deals with colour perception, separate from shapes and motion (Zeki 1993, 1999).

The moving object

Indeed the last chapter in the evolution of visual art is the depiction of movement. Impressionists and post-Impressionist painters attempted to represent motion. Excellent examples are Duchamp's, "Nude Descending a Staircase" (1912), Paul Klee's "Figures in Red" (1921) and Giacomo Balla's, "Dynamism of a Dog on a Leash" (1912), all playing with shapes giving illusion of movement. The advent of cinematography resolved the search of illusion of motion, moving visual art into a new dimension. However it all started with the astronomer Al Hazen in the tenth century who realised that a rapid succession of images could create the illusion of movement. John Ayton studied the persistence of vision, and gave a sound scientific explanation for the phenomenon in 1826. Michael Faraday in the early nineteenth century described the phenomenon, then called "Phi" by Gestalt psychologists, according to which the quick appearance of spots next to each other is interpreted as motion.

Recent neuroscientific studies confirm that indeed there is a specialised part of the cortex that deals with motion (Zeki, 1993). Despite the relative inability of painting to match the power of cinematography and video, some painters discovered that some still patterns give a strong illusion of motion. Bridget Riley's "Fall" (1963) and "Hesitate" (1964) and Isia Levian's "Enigma" (1984) provide examples of such beautiful illusions. Recently, neuroscientists have confirmed that these patterns activate the same part of the brain underlying perception of motion (Conway et al 2005). This confirms that painters had discovered that certain images activate brain processes that give the experience of motion, prior to neuroscientific experiments beginning to show how and why.

The ability of the brain to fill in for visual hints provided artificially by the artist or by direct experience was well recognised by Gestalt psychology in the early

1900s. In parallel, many artists realised this through artistic experimentation, and utilised this capacity of the brain to create stunning paintings (see for example "The Yellow Dancers" by Gino Severini 1911-12; from Cavanagh, 2005).

The ability of the brain to construct visual images of the world appears to be well embedded in the wiring of the cortex. Is it possible that such wiring may actually impose some pre-established neural "rules" to perception that may explain our Platonic idea of shapes? Interestingly, some modern artists produced works which, although they contain no specific circular shapes, are perceived as transient circles. Wilson et al (2000) used patterns produced by superimposing three square grids of dots, each rotated by 60° relative to the others. Such patterns, similar to some abstract paintings, generate illusions of circles. Thus the formation of a full visual image our brain performs in real time involves complex neural processes that are similar to what visual artists have discovered empirically over the centuries. As such, artists and neuroscientists are both explorers of how we see the world.

Both neuroscientists and artists have come to realise that the world out there appears initially to an untrained brain as a bombardment of lights, shades, colours and motions that do not make sense on their own. Superb examples may be Joseph Stella's "Battle of Lights" (1914) and most of Pollock's abstract paintings. They are reminiscent of the first experiences of the visual world described by some fortunate few who recover vision after a life of blindness. Perhaps painters have delved deep into the visual processes to a level that precedes the "construction" of a meaningful visual image.

It is often said that science and art differ because emotions are important for the latter but less for the former. The role of emotions in visual experiences is now well recognised with neuroscience showing that certain images activate not only the visual cortex that constructs visual images, but also the deepest parts of the brain involved in emotional experiences. Vuilleumier et al (2003) found that there is preferential activation of the amygdala by an "impressionistic" face rather than by a more "realistic" face. Vartanian and Goel (2004) conclude from their neuroscientific experiments that the differential patterns of brain activation, observed in the "emotional brain" in response to aesthetic preference, reveal an important feature of the brain in evaluating reward-based stimuli that vary in emotional valence.

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Kawabata and Zeki in 2004 addressed the question of whether there are brain areas that are specifically engaged when subjects view paintings that they consider to be beautiful, regardless of the category of painting (that is, whether it is a portrait, a landscape, a still life, or an abstract composition). They used brain imaging techniques to establish brain responses to pictures judged to be beautiful or ugly. They found that the orbito-frontal cortex (involved in emotions) "lights up" specifically during the perception of beautiful and ugly stimuli and that they activate differentially the motor cortex, suggesting that the brain is to some degree "wired" for aesthetic emotional responses.

These experiments suggest that, not unexpectedly, artistic experience is deeply rooted in human evolution, linking perhaps cognitive and emotional experiential values.

Interestingly and puzzlingly the history of art is also linked to altered states of consciousness. Painters under the influence of drugs (psychedelic art), diseases (psychotic periods) and mystical experiences (conditions of sensory deprivation) demonstrate well how in those conditions the sense of time and space may collapse with associated "decomposition of the self".

Does all this means that our brain is simply tricking us into believing that the "illusions" are real? Is it true that, following the Spanish seventeenth century poet Calderon de la Barca, "La vida es sueño" (Life is But a Dream)?

A hint to how best interpret this apparent paradox is, as proposed at the beginning of the article, to view visual art and vision as processes that enable us to make sense of the world. Art may well be the distillation of such processes. In this sense, neuroscience does justice to both the aesthetic and cognitive values without trivialising either. ✱

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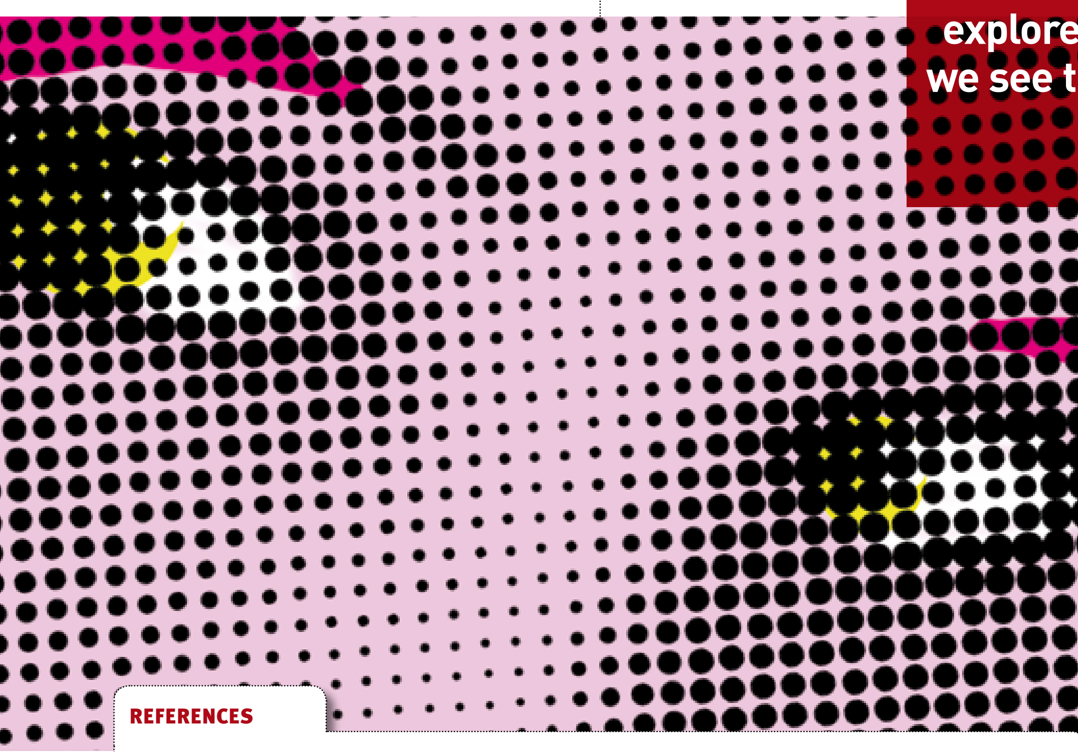

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