Journal of Research Practice
Volume 6, Issue 2, Article M11, 2010

ISSN: 1712-851X

Main Article:

The Role of Experiential Knowledge in the Ultimate Design Studio: The Brain

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Abstract

An understanding of how our experiences shape the neural networks in our brains, which condition our subsequent actions and experiences, can be useful in explaining patterns found in art and design. This is the perspective of neuroarthistory, which can be applied at different levels, from the patterns unfolding in the works of a single artist/designer to the much wider epochal patterns discovered through archaeological studies. This article introduces the neuroscientific principles of "neural plasticity" and "neural mirroring," and demonstrates their application to explain the patterns found in prehistoric, medieval, and contemporary art and design expressions.

Keywords: neural network; neuroarthistory; neural plasticity; neural mirroring; experiential knowledge; Gerard Caris

Suggested Citation: Onians, J. (2010). The role of experiential knowledge in the ultimate design studio: The brain. *Journal of Research Practice*, *6*(2), Article M11. Retrieved [date of access], from http://jrp.icaap.org/index.php/jrp/article/view/240/201

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1. A Neuroscientific View of Art and Design

There are many definitions of design, going all the way back to its origins in the Italian *disegno*, meaning drawing. Some problems, particularly practical problems, are best treated using a narrow definition, as in industrial design. Others, particularly theoretical problems, are best engaged with using a broad definition, one that includes everything that might be thought of as raising design issues, from prehistoric tools to renaissance altarpieces to modern steel constructions. In the present context it seems helpful to think of design as referring to the conception and making of objects. These objects may have little material substance, like lettering, or little material value, like tools, but they may also be extremely substantial, like buildings, or extremely valuable, like jewellery, paintings, or sculpture. Whatever the object involved, the process of conception and making takes place in one or more locations, nowadays often a design studio, and requires the application of different types of knowledge. Those who teach and study design are experts in the efficient and creative use of the design studio and in the exploitation of different types of knowledge. But there is one type of design studio and one type of knowledge of which they may not consciously be aware, although they may be experts in the use of both. The design studio I am referring to is the human brain, where all our actions have their origins, and the knowledge I refer to is experiential knowledge, or rather one type of it.

The type of experiential knowledge that I am referring to is the knowledge that we build up as a result of our own personal experiences. Such knowledge has properties that distinguish it from the experiential knowledge that we build up consciously by training and practice, and also from other types of knowledge with which we are familiar, that is knowledge that is common or knowledge that can be shared through verbal communication. Knowledge that derives only from our own experience may be ours alone. It may also be difficult to transmit to others by words. Indeed, since we may have acquired the knowledge quite unconsciously in the course of our daily activities and through our exposure to our particular material and social environment, we may not even be able to express it verbally. Others may share the same knowledge, but they do so only because they have shared similar experiences. In this way a whole community, the people living in a particular location, a street, a village, a town, or a country, may share some experiential knowledge, but the community members may never talk about it. And yet such knowledge may influence all aspects of their behaviour, including the aesthetic preferences that guide their design activities.

The reason it does so is because such experience is not only processed in the brain, it causes changes within it, changes to the neural connections and to the neurochemistry on which all our actions depend, changes which are liable to affect all our actions. Until now this process could only be sensed dimly, though often highly perceptively, as I have argued in *Neuroarthistory: From Aristotle and Pliny to Baxandall and Zeki* (Onians, 2007a). Now, because of advances in neuroscience made by scientists such as Zeki, it is possible not only to realise the way such experiences cause changes in our neural connections and neurochemistry, but also to understand how such changes are liable to modify everything we do. This is why we can talk of neuroscience allowing us to go inside the brain and reveal the way it functions as a design studio, so making possible the emergence of a new type of art history, neuroarthistory.

2. New Knowledge of the Brain: Neural Plasticity and Neural Mirroring

What then is the new knowledge of the brain that can sustain a new discipline of neuroarthistory? The basic facts are simple, but they reveal an astonishing complexity. We now know that each of us is born with about 100 billion neurons, that each of these neurons can have to up to a 100,000 connections with other neurons, and that these connections are constantly being made and falling away during our life (Figure 1). We also know increasingly which neurons or groups of neurons support which physical or mental activity. For example, we know which groups deal with signals from each of our senses, with the area of the brain that deals with sight being placed at the back of the head and that which deals with hearing at the side. We also know how the position in the brain of the neurons dealing with sensory signals from our limbs relates to those that send out signals to the same limbs to perform motor actions. We know that these arrangements of collections of neurons with specialised function are determined by the genetic coding of our DNA and that the same coding establishes the principles by which they operate and the principles by which connections between individual neurons will form or fall away in response to our experiences.

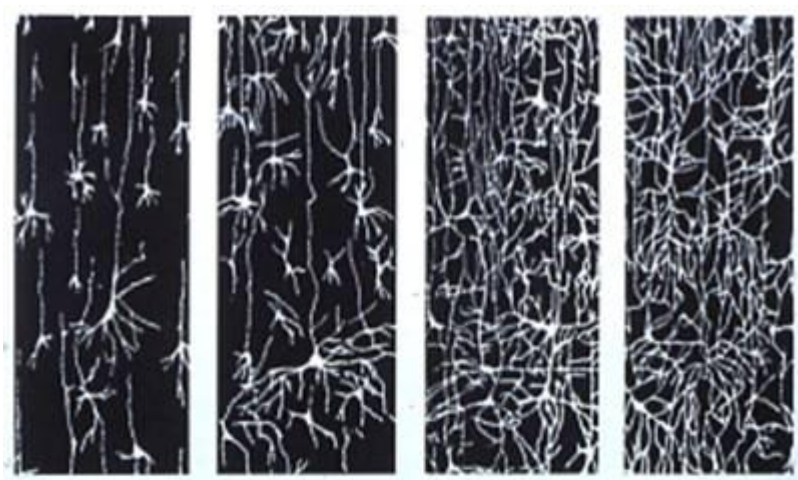

Figure 1. Formation of connections between individual neurons in the first 2 years of life.

This last principle is the one best captured through the concept of *neural plasticity*, a phenomenon whose importance emerges everyday more clearly, so changing our whole view of the brain. It thus used to be thought that the brain was a sort of machine that, once formed in childhood by a process of biological programming, remained more or less stable. It is now realised that it is an organ in a state of constant change throughout our life, with connections between its 100 billion neurons being formed and falling away in response to changing experiences, endowing each individual with networks supporting specific inclinations and skills. The most important aspect of neural plasticity for those studying art and design is the way our neural networks are reshaped by our visual experience (Tanaka, 2003). Each time we look with attention at anything, such as an object, new connections are formed between the neurons involved, connections that improve our ability to see that object and give us a preference for looking at it or any other object that shares similar attributes. This means that if we know, or can reconstruct, what an individual was looking at with particular attention, whether it was part of their natural environment or was man-made, we can become aware of an important factor influencing their aesthetic choices, whether that person was a maker of art, a patron of art, or a viewer of art.

A second area of knowledge that is particularly useful when studying art and design is that relating to so-called “mirror neurons” (Rizzolatti & Craighero, 2004). It was known for a long time that we have separate groups of neurons in our brain that fire when we move a particular limb, such as a hand or a finger. Then, in the early 1990s, an Italian team of neuroscientists discovered that, in our close relatives, macaque monkeys, some of these neurons also fire when one individual merely observes another moving that limb, although they themselves make no movement. Soon it was realised that such neural mirroring is even more important for human beings. For example, these same mirror neurons help us quite unconsciously to learn highly specific movements. And since these neurons are also associated with an ability to understand why the action is performed, they are also an aid to our understanding of what goes on in other people’s minds. These neurons lie behind human beings’ astonishing ability to imitate each other without any formal instruction being involved, as when a child learns movements from its parents. For the art and design historian they help us to understand many aspects of art related behaviours. For example, they make us aware of how the body languages of artists and designers, which are highly variable, may be influenced by the movements of those individuals to whom he or she has given particular attention.

It is these two types of knowledge that I want to draw on for the rest of this article, as we explore design processes in a wide range of contexts from prehistory to the present. My purpose is to show that they shed much light on the workings of the brain as a design studio, whether the brain involved is that of a remote ancestor a million years ago adapting a stone to serve as a tool, or a contemporary artist making a painting or sculpture.

3. Brain as a Design Studio

3.1. Stone Tools

We can begin by considering the neural processes that led to the emergence of the archetypal stone tool, the so-called Acheulian hand axe, a type found as early as 1,500,000 years ago, but which remained in common use worldwide for hundreds of thousands of years (Figure 2). It has long been realised that such axes share many of the properties of the human hand, shape, dimension, and so on. What neuroscience can add is help us to understand why this is so. The use of stones as tools is not unique to humans, being found already among chimpanzees. What was new among humans was the habit of changing the shape of stones so that they were more effective in helping them achieve the goals that they were trying to achieve with their hands. And this is where the brain as a design studio comes in. When our ancestors discovered that stones could enable them to perform tasks that their hands alone could not perform, they would have started unconsciously looking at such stones in a different way. For one thing, their neural mirroring systems would have led them to imagine the stone taking over some of the functions of the hand. They would have literally felt about the tool what they felt about their hand. And for another, as they looked back and forth from their hand to the stone the plasticity of their visual system would have equipped them with neural networks that would have provided the mental templates that guided them as they shaped the stone. It is because these were universal neural properties that such axes are found throughout the planet for over a million years, wherever human beings lived.

Figure 2. Acheulian hand axe (source: Peter A. Bostrom, Lithic Casting Lab. Com).

But not all such axes were the same. Why is that? Again neuroscience can take us into the studio of the brain and shed some light on what went on what might have occurred. Why, for example, are the axes from Boxgrove in Sussex from around 600,000 BP (*Before Present*--a timescale used by archaeologists) more symmetrical and regular than any others produced for another 200,000-300,000 years? The answer probably lies in the way the brains of their makers unconsciously responded to the exceptional visual properties both of the stone they were using as raw material and of the environment in which they lived. The stone they were using was high-grade flint, a silica of such consistency that it behaves like glass, always reacting to a particular type of blow in the same way. This would have meant that someone working that material would have observed regular patterns emerging in the flint, and since, as has been known since the discoveries of gestalt psychologists in the 1920s, we get pleasure from looking at such regular patterns, the individuals working with that material would have found themselves unconsciously reinforcing the natural regularity. The taste for regularity, which distinguishes these tools, was also encouraged because they lived at the bottom of a chalk cliff which delivered a regular supply of such flints. The makers certainly seem to have so enjoyed making the tools that they gathered piles of flints around them and from them created a surplus of tools. Repetition of pattern within the individual tool was associated with repetition of the tool. Still another factor behind the distinctiveness of Boxgrove tools may have been the visual properties of the site itself. Since the makers lived on a flat piece of land at the bottom of a vertical cliff which had a sharp horizontal top, they lived in an environment that was also much more regular and geometrical than that of their contemporaries, and visual exposure to such an angular space, would have strengthened their taste for regularity, much as living in the angular world of the modern city strengthened the taste for angular modernist design in twentieth century Europe and America.

If the tools of Boxgrove in the Lower Palaeolithic are characterised by a unique regularity, those of the Upper Palaeolithic are characterised by a unique variety. The increase in variety had been continuous, as new types were developed, but became much more rapid after Homo Sapiens Sapiens arrived in Europe around 35,000 BP. What factor caused this sudden change? Archaeologists, who use the representational imagery they made as evidence of a new level of intellectual development, tend to think that it is because the new humans were more intelligent and talked to each other more. But in my view crediting something to a general new intelligence is hardly satisfying, and I would see the reasons for the emergence of new tool types as being suggested by the animals they represented in their art, whether the sculptures of the Swabian Jura in Southern Germany or the paintings of Chauvet in southern France. The species chosen are neither exclusively the prey that they desired to eat nor the predators they feared, as we might have expected. What all the animals, both predators and prey, have in common is impressive tools, not just horns, tusks, claws, and teeth, but fur coats and hunting intelligence.

Why should members of the human species have concentrated so much on animals remarkable for their tools? Humans had of course always lived with animals, but they had probably never looked at them with such interest. Europe, where the art and the new stone tools were made, was rich in game, but extremely cold, unlike Africa where these hairless individuals had started their journey. In these circumstances their neurally driven tendency to mirror and empathise with other humans led them to look at the animals whose equipment they envied with a new intensity, and as they worked stone to make their own tools the same neurally driven interests led them to make tools which mimicked the capacity of the tool kits of the different animals, their capacities for scraping, cutting, piercing and so on. From watching animals they may have also unconsciously acquired specific techniques such as weaving, which also appears at this time. As they gazed with admiration on the nests that birds wove with their beaks and the nets that spiders wove with their extruded filaments, the mirroring resources in their brains would have led them to imitate their successful technologies. The result is the production of a rich new material culture, including many different types of tools, and the first woven objects.

3.2. Painting and Engraving

Neuroscience also helps us to understand the most exciting spin-off from this interest in the tools of other animals, the emergence of another technology of enormous future importance, that of two-dimensional artistic representation. The earliest representational paintings anywhere in the world are those from the cave of Chauvet in the Ardèche in southern France and they are remarkable for two reasons. First, at 32,000 BP, they are the earliest cave paintings, twice as old as Lascaux, and second, they are also much the most life-like. Indeed they are not only more lifelike than the Lascaux animals, which look like stuffed toys; in some ways they are also more lifelike than the drawings and paintings of Leonardo. There are no available theories which explain why this is so. All archaeologists do is claim that there must have been many earlier images which got better and better over time, but which are now lost. But if that is so, why did not the improvement continue?

As I have argued elsewhere, neuroscience explains not only why these are so naturalistic because they were the first, but also why all later images are less lifelike (Onians, 2007b). My argument is that it is because humans looked at the animals they admired with such unprecedented intensity that they developed neural networks that were like photographic negatives, and it was because these mental images were so strong that they projected them onto the cave walls. The reason that all later images, including already the later work in the Chauvet Cave are less lifelike is that once they had made the lifelike images they started to admire them and the more they looked at them the more they degraded their original neural networks. By looking less at real animals and more at their representations of them what began as lifelikeness was transformed into schematisation. In other words the story we have all been told that art starts out schematic and becomes more naturalistic as the result of conscious effort is the reverse of the truth. The first images are the most naturalistic because they are based on superior experiential knowledge.

The same sequence of stylistic development can be found again later. When, after its descent into schematisation, European art does become more naturalistic again first with the Greeks and a millennium and a half later with the Italian Renaissance; it is only because artists started to look at living creatures with the intensity that the artists at Chauvet had done long before. The main difference is that while the living creatures that interested the artists at Chauvet were four-footed animals, those that interested the artists of Greece and the Renaissance were human bipeds. There is also a correspondence in what happened after this burst of naturalism. As at Chauvet, when their successors started to look more at the art that they had produced than at living creatures, their art too became more schematic. Since the principles of neuroscience are relatively stable, given constancy in other aspects of the environment, similar experiences could be the basis for similar developments in art and design.

But one may ask: What was it that led to the inhabitants of this cave to start to make marks on the wall in the first place? Here again neuroscience can help. One of the features of the cave is that there are several places where human marks and colours are placed near or on top of marks and colours made by bears. In one place we see how a bear has scratched the wall with its claws, and a human has later made an engraving of a mammoth on top. And in another we see how a bear has put its muddy paws on the wall and later a human has applied pigment to his or her hand and made similar marks, even building up an animal silhouette with them. Such imitation of bears by humans would have seemed surprising before the discovery of mirror neurons. Now, we know that the sight of the marks made by the hands of the bears could have been liable to activate the mirror neurons in humans causing them to replicate the actions of the bears. After all we have mirror neurons because they help us to learn from our elders as children and the humans must have looked at the larger, smarter, and better equipped bears the same way they looked at their elders. This is why they copied their techniques of scratching and colour marking, so making the first engravings and paintings.

3.3. Architecture

Painting and engraving are two design activities which seem to have been encouraged by looking at animals. Architecture is another. The first permanent buildings which embody the regularity and symmetry found in all later architectural traditions around the world are the houses constructed out of mammoth bones in the Upper Palaeolithic in the steppes of what is now the Ukraine. The best examples are the buildings from Mezhirich, from around 15,000 BP, now reconstructed in the museum in Kiev. What is remarkable about them is that the properties that distinguish them from all earlier structures constructed by our ancestors are ones derived from the bodies of the mammoths whose bones provided their building materials. They must have admired the strength and stability of the great beasts from a distance, and when they killed one and were able to crawl inside it to extract its organs they must have realised that it had many of the structural properties they desired in their own homes. Their intense looking would have led them to empathise with the great creatures and to construct buildings that shared their organisational principles. Their walls were round, reflecting the rounded nature of the mammoth's skeletal rib cage and, as in the mammoth skeleton, similar bones were placed in rows. In one section of wall jaw bones were piled up like vertebrae, in another vertebrae themselves were used. In other cases the wall was marked by a circle of pelvises. The huts like the mammoths had a clear axis with an entrance at one end and in one case mammoth skulls were placed either side of the opening with the tusks pointing upwards to make an entrance arch. In front of the entrance a row of leg bones was also erected, providing humans with the same security that the mammoths obtained by standing in a defensive line. The experience of looking at the mammoth skeletons must have had such an impact on the neural resources of the mammoth hunters that they took from them many of the principles governing the designs of their homes.

3.4. Sculpture

The use of neuroscience thus enables us to understand why painting, engraving, and architecture first appear in the forms they do at particular places and at particular times. It also sheds light on the principles governing the stylistic variations that soon developed, as in the sculptural representation of the female body. Figure 3 shows a figure from Europe, the so-called Venus of Laussel, about 22,000 years ago, and Figure 4, from Kamikuroiwa in Japan from about 10,000 BC. The European figure is large and fleshy and carries a large hard object. The Japanese figure is small and flat, with prominent hair and skirt. Interpreting the difference in terms of the principles governing neural plasticity, we would expect it to relate to differences in the objects to which the makers gave most visual attention, and one such difference is clear. The inhabitants of Europe at this date desired and pursued large herbivores which they killed and butchered using large stone tools. In Japan by contrast, the diet was of small mammals, birds, and fish, which were often caught by nets, nooses, and lines, all made of fibres, which thus became the principal object of their desire. That is probably why the European gives the woman the fleshy massiveness of a large herbivore and the Japanese takes delight in her fibrous hair and skirt. Probably the Japanese had looked so intently at fibres that they had developed neural networks that gave them a special interest in them and a neural chemistry that meant looking at them gave them particular pleasure.

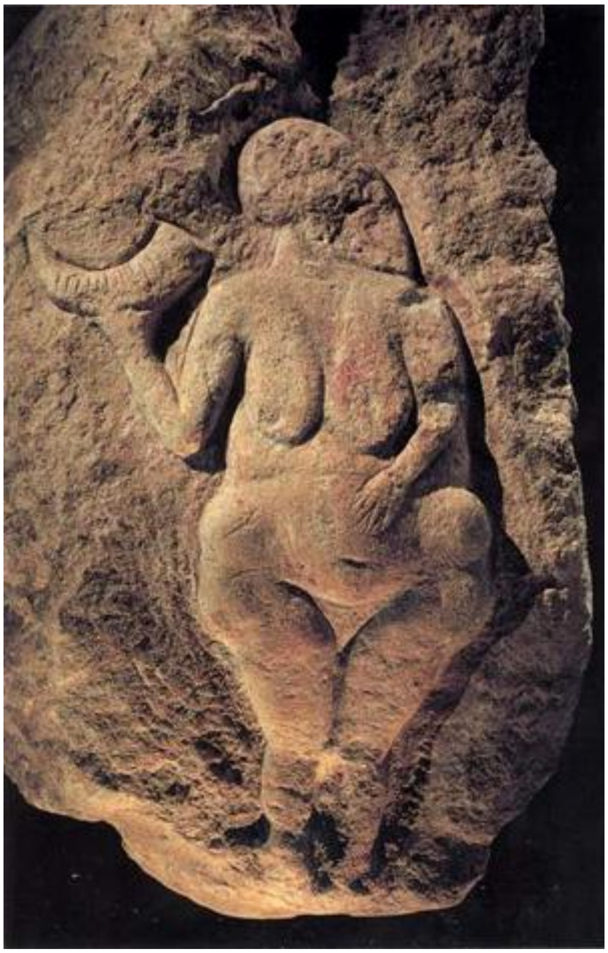

Figure 3. Female figure, Venus of Laussel, c.22,000 BP (source: www.seshat.ch).

Figure 4. Pebble from Kamikuroiwa, Japan c.10,000 BC.

3.5. Textiles

The currency of these preferences in Japan can also be confirmed by later art. They are first apparent in the distinctive ceramic tradition known by the word for string, *Jomon* (Figure 5). String patterns are found in other early pottery traditions but only in Japan are they so prevalent as to have provided the name not only of a pottery style but of a whole period of history. Fibres meant more to prehistoric Japanese because of their ecology and they continued to do so, especially after the arrival of silk. Indeed the original interest in visible fibres led to the Japanese developing a taste for fibrous textiles which survives to this day in the couture of their most famous fashion designers. The continuing importance of fibres in Japan is also illustrated by the prominence of fibre arts on the Japanese art scene, a position unknown elsewhere, which is why a recent exhibition, *Cloth and Culture* at my home institution, the Sainsbury Centre at the University of East Anglia, UK was built around a group show of Japanese fibre artists.

Figure 5. Middle Jomon vase, detail, c.5000 BC.

I also was reminded of the roots of Japanese interest in fibres at the last *Documenta* exhibition at Kassel, where the Japanese artist, Ryoko Aoki, had made an image of a woman wearing a skirt in the shape of Mount Fuji (Figure 6). The preferences apparent in the Kamikuroiwa pebble are still alive today. Equally revealing of Japanese neural tastes is the reference to Mount Fuji. Only in Japan, where fibres were a long-standing obsession and where the great snow covered cone dominates the modern capital, would an artist possess neural networks that allowed a flimsy skirt to recall an extinct volcano. The unique experiential knowledge of a Japanese woman artist turned the design studio of her brain into a setting for the creation of a skirt inspired by the shape of the volcano which figured prominently in her visual environment.

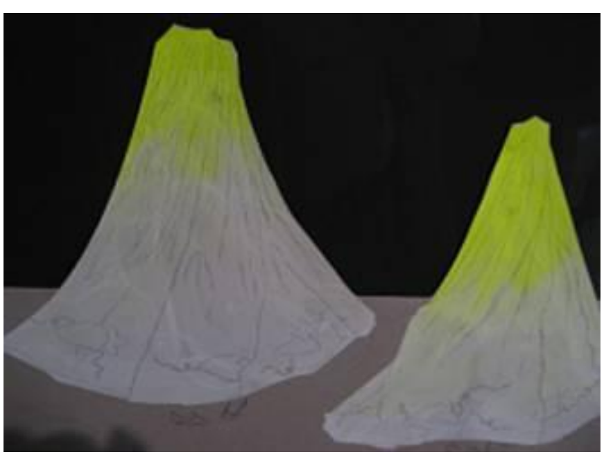

Figure 6. Watercolour by Ryoko Aoki (b. 1973, Japan), contemporary.

3.6. Body Armour

The very different experiential knowledge of ancient Greek males gave them a quite different approach to human clothing, as is well suggested by this sixth century BC vase painting (Figure 7). In the scene on the vase we see warriors putting on bronze body armour and in the decorations of two of their shields we can see designs which suggest the origin of the idea of clothing themselves with such hard metallic forms. One shield shows a scorpion and the other a crab, both creatures which have hard exoskeletons. Warfare was evidently so endemic in Greece, that people looked with great admiration and envy at those creatures in their environment that were best equipped both for aggression and defence and so were predisposed to imitate them. Not just the activities of painting and engraving, and the construction of regular permanent homes, but the making of textiles and of body armour were all influenced in significant ways by the unconscious experiential knowledge available in different communities.

Figure 7. Warriors arming, kalyx crater, Attic c.525 BC.

3.7. Physical Posture of Artists: European and Chinese

The vase painting also demonstrates how important military activities were to the ancient Greeks and they have continued to have an exceptional prominence in European culture. Every European was likely to pick up some exceptional experiential knowledge of warfare and this had some surprising influence on their artistic activities, as we can see from this sixteenth century print showing a painter in a typical pose (Figure 8). The artist stands in front of a panel vertical on an easel, his brush in his right hand and palette in the left, and it is easy for us to take the stance for granted as natural, but it is not. No painters anywhere else in the world ever stood like that. If however we recognise in the pose an imitation of the knight with his sword and shield we understand what is going on--a correlation strengthened by the artist's choice for subject matter of a knight in his ultimate glory. Knowledge of the way mirror neurons affect bodily deportment would suggest that Renaissance artists would have been inclined to imitate knights for exactly the same reason that Palaeolithic artists imitated bears, because knights were in crucially important ways more effective and materially successful than they were.

Figure 8. Painter in studio, engraving, sixteenth century Flemish.

Neuroarthistory works not by apercu but by principle, inviting us to explain other typical artistic poses in a similar way, and the same knowledge of mirror neurons may help us to explain the typical pose of Chinese ink painters (Figure 9). While in Europe, where military values were supreme, ink was always applied with a sharp instrument such as a pen, even more like a sword than a brush, in China it was just as consistently applied only with a brush, whether used for painting or writing. This contrast in implement was matched by a contrast in the painter's pose, since the artist sat and dragged ink from a pool-like container onto a horizontal sheet of paper or silk. In asking whose body language he might be imitating I proposed that it was probably that of the farmer irrigating his rice field since that was the source of wealth for rich and poor, and, although neuroarthistory does not rely on texts to come to its conclusions, I was not disappointed when I discovered that the character for painting in China is built around the sign for field. It was as natural for the Chinese artist to feel that his activity was analogous to that of a farmer as it was for a European artist to think of his as analogous to a knight. And it is worth reflecting on what this means in terms of the artist's sense of self. It is as if the European artist stabs at his canvas or panel like a fencer, while a Chinese artist waters his sheet like a field to make it more fertile for his imagination. Everything they design in their brain studios is inflected by the experiential knowledge of the physical deportment of more admired or essential members of their society.

Figure 9. Painter at work, China, twentieth century.

4. Experiential Basis of Gerard Caris' Pentagonism

Until now my argument has not been one I could substantiate by calling any of the designers involved to witness, but recently I had the opportunity of testing the approach presented above on the work of a living artist and of discovering what he thought of my findings. The opportunity came about when I was invited by the Dutch artist Gerard Caris to write something about his work. I had no contact with his work before and had indeed never written about twentieth century art; so the challenge was considerable. Caris' own view of his art is clear from his Web site:

> I hereby like to present my work which has been a concentration on pentagon dodecahedra forms, the five pointed star shaped by the diagonals of the regular pentagon and the rhombohedra taken directly from the dodecahedron, over a period of forty years as new and authentic artistic art movement like a new ISM. (Caris, 2009)

This statement might seem to indicate that his work grew out of a conscious interest in geometry, especially in the geometry of the regular solid, the dodecahedron, with its twelve faces consisting of regular pentagons. But other things he has said suggest that his art may have had more obscure origins. Thus his reflection that his pentagonism was originally "Intuitively conceived in a spontaneous composition titled *Creation of the Pentagon*" (Caris, 2009)raises the question of what might have been the source of his "intuition." According to the approach advocated here, we might look for influence from his experiential knowledge. What do we know of his experiences before *Creation of the Pentagon* (Figure 10)?

Figure 10. Creation of the Pentagon, print, 1970, Gerard Caris (source: gerardcaris.com).

Caris had begun life in the early 1940s as a passionate engineering trainee and in the next 20 years he had had many jobs all over the world, often involving some sort of steel fabrication. Most of that work had been routine, but in 1961 he was given a unique responsibility, to be the project manager in charge of the construction of the "horn antenna" at Andover, Maine, USA, designed by Bell Laboratories to send and receive signals via the new Telstar satellite. This post brought Caris in contact with the cutting edge of science. Satellite technology, depending on sophisticated rocket-launching facilities and complex electronics, was new, and so was the technology of the horn antenna. Ultimately the completion of the Andover facility, which was designed to receive and transmit television pictures, inaugurated the era of global communications, embracing not only television and radio, but many other forms of voice and data transmission, including mobile phones.

All this, though, was in the future when Caris was overseeing the construction. What was new in his experience was the forms of the components involved, both those of the strange horn antenna itself and of the nearly spherical dome in which it was housed. Not only was the dome, with its structure of curving lines, their interstices filled with a light material, quite unlike most buildings, but the horn antenna itself was an extraordinary composite of conoid cylindrical forms suspended in a cradle of metal bars none of which was horizontal or vertical and none strictly parallel (Figure 11). This installation was to be Caris' "baby" and if we imagine the young Caris gazing repeatedly first at the drawings for this construction and then at the construction itself with the passionate intensity manifest in his earlier photograph, it is easy to see how the experience might have so reshaped his neural resources that he would have acquired preferences which were unique.

Figure 11. Antenna at Andover, Maine, USA, 1961.

The importance of Caris' experience when constructing the horn antenna is enhanced by the knowledge that at the time he was already becoming interested in art. Between assignments in the oil industry he spent time in New York where he made contact with leading artists and, on March 17, 1960, in the same city, while on leave from Arabia, he was present at the intentional destruction of Tinguely's *Homage to New York*. When, a few months later, he found himself supervising construction of the Andover antenna, he cannot have failed to be struck by the similarity between it and Tinguely's fantastic machine. Both consisted primarily of open structures in which wheels and rods figured prominently, and both he would have experienced using neural networks already formed by repeated exposure to drilling rigs and other openwork steel structures typical of the oil industry. The correspondence was all the more likely to remain in his brain as an artist because the Andover antenna was almost his last major responsibility before his return to study, culminating in 1969 in a Master of Fine Arts (MFA) at University of California, Berkeley, USA. His artistic training gave him the opportunity to work with leading figures such as Kitaj, Hockney, and Diebenkorn, and it was with their charismatic example before him that he began making the works which would be the foundation of his later development. Thus, a sequence of silk screens, *Birth of Form* (1968), led on to the series *Creation of the Elements* (1969), before the production in 1970 of the work that he later described as "intuitively conceived" and a "spontaneous composition," *Creation of the Pentagon*.

It is unlikely that Caris was conscious of any of this, and it is, in any case, irrelevant to this argument whether he was. The claim here is that, regardless of his conscious intentions, his art is likely to have been affected by his earlier experiences. The principle of neural plasticity means that the formation of his neural resources is likely to have been exceptional. Each individual's neural network is unique, being partly related to the objects to which they are exposed and his must have been unlike those of other artists, having been exposed to a unique sequence of phenomena, which all shared similar properties. When he saw *Homage to New York*, he must have looked at it with networks formed by working with openwork steel structures and when he came to work on the Andover antenna he must have looked at it with networks formed by exposure to both. Their responsiveness to the antenna will thus have been greatly heightened and this would have made it more likely that the experience of the antenna would have eventually influenced the movements of his hand. Of course those movements were also influenced by his exercises as a student under the eyes of his teachers, but it is not surprising if at the moment when he, like other MFA candidates, was looking for a way to make a personal contribution to the history of art, responded through those neural resources which were his and his alone.

It was probably not only the antenna that affected Caris. The Telstar satellite itself also seems to have absorbed him. Although not dodecahedral, its multifaceted spherical geometry (Figure 12) gave it many of the properties of the regular solids that a few years later were to absorb the engineer-turned-artist, and when he became involved with architecture, the satellite's influence on his creations becomes palpable. From the early 1980s Caris was using pentagons and dodecahedra as the basis for elegant and compact housing designs and in the models (Figure 13) the transparent sections of walling read very like the solar panels with which the satellite's exterior was gridded, while the white framing structure recalls the similarly coloured interstices between the panels.

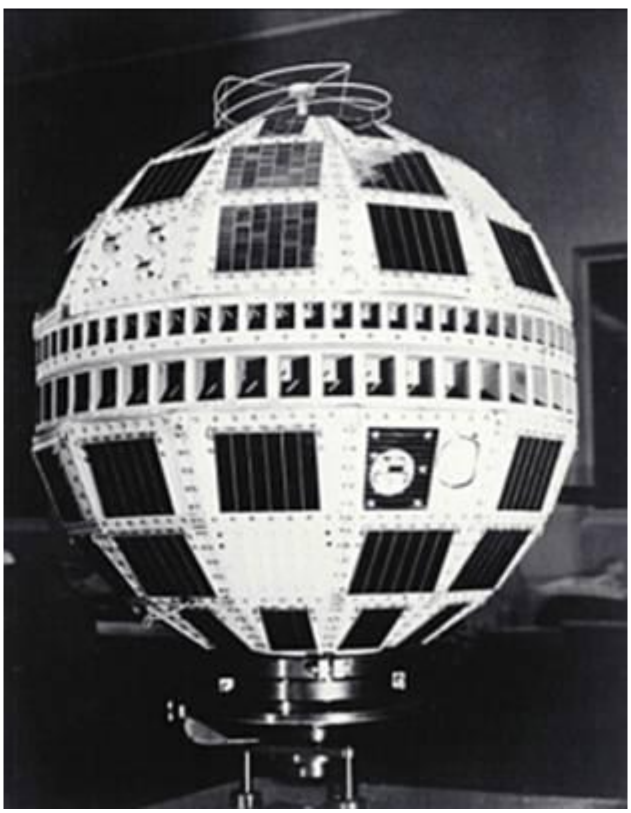

Figure 12. Telstar satellite, 1961.

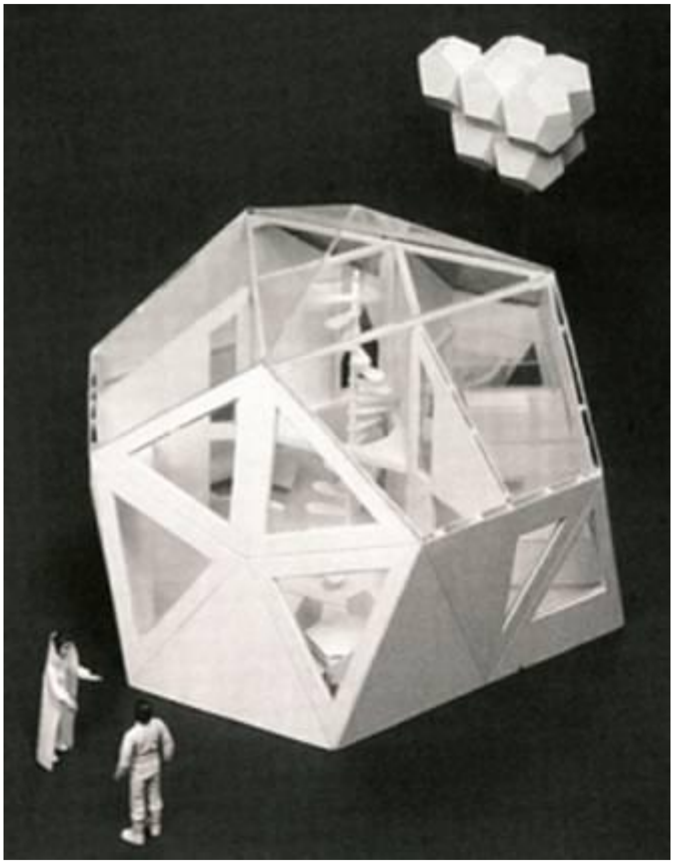

Figure 13. House, model, Gerard Caris, c.1980.

In drawing attention to the potential importance of the purely passive exposure of Caris' neural networks to the Andover horn antenna, there is no intention to diminish the value of Caris' conscious and highly intelligent theoretical pronouncements, nor to doubt the light that such pronouncements shed on his work. His interest in the pentagon as such and the dodecahedron as such, do not have obvious sources in the Andover project and can only have been the product of intense reflection. My point is only that his initial art-making, like the conscious intellectual activity that it inspired in him, had unconscious roots. Both were sustained by uniquely personal neural resources, those formed as the result of his working on the Andover antenna project immediately after his viewing of *Homage to New York*.

In the case of Caris, I chose to emphasise the importance of the project management at Andover, because I sensed a resonance between the antenna and his later work, but it would be possible to come up with many other experiences which might have had as much or more affect on him. For example, knowing that the Sphinx porcelain factory was perhaps the most well known industry in Caris' hometown, Maastricht, and sensing a similarity between his repetitive patterns of regular solids (Figure 14) and the rows of moulds and finished sanitary ware with which the factory would have been filled (Figure 15), I wondered whether that too affected him. Clearly, if his family was in any way involved with the factory or if he lived near it, this would have been more likely to be the case, and, since developing this idea I have discovered that his grandfather was indeed a pot-maker there. The young Caris' head was likely to have been filled with rows of regular ceramic shapes long before it was filled with geometrical metal constructions. His boyhood spent in Maastricht may have been as important for his innovative contribution to the history of art as the short time he spent in Maine.

Figure 14. Sculpture, Gerard Caris.

Figure 15. Sphinx factory, Maastricht, The Netherland, interior view, c.2000.

This commentary on Caris' activity as painter, sculptor, and architect does not draw directly on his ideas, but in its emphasis on the importance of early and unconscious experience it does resonate with things he said in a talk at the Parsons School in New York in1981. There he criticised the prevalence of rectangles and cuboid forms in contemporary architecture and recommends the introduction of the dodecahedron on the grounds that it accommodates "the postural positions of the human body allowing for identification with our very first beginnings in the womb" (Caris, 1981, p. 4). His claim is, he admits, conjectural, but he insists that "No matter how vaguely reminiscent of these early experiences, they are still operative unconsciously, affecting us mentally and emotionally" (Caris, 1981, p. 4). Caris' statement here might be taken to indicate that he would be sympathetic to my commentary, and that this is true is apparent from his response to me when I sent off to him the article I had written on a Friday. By Saturday morning he had replied that he had spent years trying to persuade museum directors that his work was "not an exercise of applied mathematics, nor a mere utility of fivefold symmetry, but the result of a combination of seemingly unrelated experiences in professional jobs and studies" and he could now "through the knowledge of neural plasticity" understand how this was so (G. Caris, personal communication, March 14, 2009).

Of course the fact that Caris approves of my view of his work does not mean that I am right, nor does it demonstrate the merits of my approach, but it does suggest that there is some substantial resonance between the views presented here and the brain of at least one designer. And his reference to his earlier sense that his work was the product less of conscious mental activity but "a combination of seemingly unrelated experiences in professional jobs and studies" points directly to the importance, at least in his own life, of experiential knowledge.

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Received 13 August 2010
Accepted 8 February 2011