Why Music? Is Music Different from the Other Arts?

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TRANSCRIPTS

The Neurohistory of Art: How Neuroscience Illuminates Individual Inspiration

Professor John Onians

Michael Trimble: After the introduction we had the ground has been partially laid as to where the rest of the meeting's discussion may move towards. There's another 'neuro' I should have added to neuroaesthetics and neuroecomonics, which is neuroarthistory, which is linking together neurology and art in a historical sense. John Onians is now going to talk about that, probably with some excerpts from his book. I asked how I should introduce him, but in fact I have to go no further than to say that he is Professor of World Art. What more could you want?

John Onians: If I was a Homer writing an early Greek epic, my performance would begin: 'Sing O Muse of neuroscience, of how it illuminates inspiration.' The first lines of the Odyssey and the Iliad are of that ilk. By crediting my voice to a Muse, an Olympic deity living on Mount Parnassus, I would hope to convince my listeners that the words I spoke came not from me but from a higher divine source. Later Greeks would express the same idea by suggesting that inspiration came in the form of mania, a madness that was sent by Dionysus. The most widespread conceptualisation of such external influence was through the Greek 'empneusis', literally 'breathing into', which implied that the breathed voice of the poet was not his, but that of a higher being. What all these expressions communicate is that whatever normal people felt about their conscious activities and whatever they (the poets and musicians) may have felt about the rest of their actions, when it came to their highest artistic expressions, they were not in conscious control. Nor were they alone in this. I think that all creative individuals have felt the same way, even boring academics like us.

In the field of art, this sense of how most powerful expressions come from the processes of the brain of which we are unconscious, is well taught by Leonardo when he describes, and I quote, how 'judgment is powerful enough to move the hand of the painter', and by judgment he is referring to an unconscious faculty of the brain. Leonardo knew enough about nerves and enough about the brain to recognise that the processes that guided creativity were ones of which the artist was unconscious. Picasso captured the same idea when he said 'I don't seek, I find'. The creative individuals of the past have always known that the processes that lay behind their greatest works were inaccessible to the conscious mind and so beyond formulation in words. The same is true today. The only difference is that now, thanks to advances in technology in areas such as scanning, we can have access to some of the mind's hidden resources using neuroscience, as we can see in this comparison of professional artists and non-artists doing the same task.

Now since there will be some, even in this enlightened audience, who are already feeling, if not angry then at least uncomfortable with the idea that

neuroscience can help at all in the understanding of the brain's highest creations, I will try to explain the limits to my enquiry by spelling out what I am not doing. Firstly, I am not making any claims that I have found the neural correlate of consciousness. Speaking personally, it seems a term far too vague to have much use analytically, being most often used as a box in which we can hide things we want to keep secret. Secondly, I'm not looking for the neural correlates of beauty as a universal. That is an enquiry I leave to the practitioners of neuroaesthetics. Thirdly, I am certainly not looking for the neural correlate of Muses, mania or empneusis, some neural Parnassus. It doesn't exist. What I am looking for, are a few of the neural correlates of some aspects of the type of supreme creative activity that has given rise to those concepts. My enquiry is cautious, even reverent. I must admit that when, twenty years ago I started out, I was myself worried that I would diminish my own reverence for the greatness of art and my admiration for the power of the artist. One of my great delights has been that my reverence and my admiration have instead greatly increased. The little insights that I feel neuroscience have given me into a few aspects of the act of creation have only made me aware of the scale of the challenge we face in trying to explore the myriad other aspects that remain to be examined.

So why did I begin using neuroscience? My inspiration, if you'll excuse the word in a prosaic context, was the change in my department's name, because of the worldwide range of the University of East Anglia's Sainsbury Collection which you see here, from Art History, to World Art Studies. This meant looking at art worldwide, from prehistory to the present and asking new, general questions such as: why do humans make art? And why do they make it differently in different times and in different places? It was to answer these questions that I turned to neuroscience. When I started my enquiry in 1992 I had no idea of what help neuroscience might offer. I certainly had no idea that over the next two decades it would advance so fast that it would be able to offer me a real help in answering art-historical questions, allowing me to make possible, a responsible neuroarthistory.

Now, the first way in which neuroscience transformed my point of view was by offering me a much richer model of the mind than any available elsewhere. The realisation that we're all born with a hundred billion neurons, that each of those neurons can have up to a hundred thousand connections to other neurons, that those connections are being made and falling away all through our life, as we see here in an infant's visual cortex, in response to every experience we have, whether they are sensory exposures or physical actions or more complex mental events such as relationships, feelings or thoughts, and that changes in those experiences also cause variations in the electrical or chemical communication between neurons was extremely exciting.

The brain, I found out, was as complex and infinite as God or the universe but could still be explored in its details. Neuroscience offered me a model of the mind much more satisfying than any other, because it was of infinite complexity and constantly changing. Neuroscience also made me aware that these properties of the brain were coded for by our DNA, having been selected for because they favour the survival and well-being of those who possess them. We may now use our brains to compose operas, design computers or follow neutrinos from Geneva to Rome, but the resources we use to do these wonderful things were originally selected by evolution, because they helped us when we were hunter-gatherers with such basic tasks as finding food, making friends, mating and nurturing young. Discovering that my brain, like that of all humans, was ultimately driven by such needs, helped me to appreciate why looking at paintings, reading novels and listening to music engages us so intently.

Understanding the links between the cerebral and the visceral made me realise why the arts have such power to move us. There were many revelatory moments in my voyage of discovery. One was realising the importance of the principle of neural plasticity, that is the property of neurons to grow new connections in response to use. Which means that the more frequently we do something, and the greater the attention with which we do it, the more the neural networks involved will increase. As we see in this slide showing the enlargement of the areas of a monkey's brain involved in processing sensations from the tips of the middle fingers caused by repeated touching over a few weeks. Another was the recognition of the phenomenon of neural mirroring first identified by Rizzolatti and his team in Parma in the early 1990s when they observed that a group of the pre-motor neurons that normally fire, and you see them firing here, just before an individual makes a particular hand movement, also fire when the individual merely observes that movement in another monkey or human.

More recently it has been satisfying to me, as a humanist interesting in variations between individuals, to learn that neural plasticity does not operate in a mechanical way. The degree and speed of formation of new connections depends on the attention behind an action. As we see in this electron microphotograph published in Nature just over a year ago, of the transformation of neurons in a mouse's motor cortex as it confronts a new task. The neurons of all individuals acquired new spurs on the first day that the movement was attempted. That is really important; even as you come here, as you listen to these talks, everything you see here is liable to cause structural changes in the brain, and when these mice were just making a particular movement, already on the first day there are growths emerging from these neurons which will or will not become fundamental connections enabling the movement to be fulfilled. But only in some did the spurs turn into robust connections and establish the ability to complete it. In others the spurs died back and the ability was never acquired. In other words, it's not sufficient simply to do something, but you've got to do it with the attention with actually establishes and causes changes. All of which I found extremely promising because it meant that I had what I needed as a historian – a model of the mind that was not universal but individual.

The relevance of such a model is well brought out by looking again at the scans of the brains of a non-artist and a professional doing the same task – copying a portrait. Although to the external observer they both seem to be doing the same thing, the scans reveal that the neural correlates of the activity were very different. Thus in the non-artist's brain, the part that is most active is the visual cortex at the back of the head while in the professional there is much less activity there and much more in other areas further forward. The amateur needs to look very hard because he is trying to draw a face for the first time. The professional, because he has done that many times, has laid down neural resources, which he can immediate call on, in such areas of the brain as those concerned with hand movements, in the middle of the brain, and with planning at the front. The professional artist was essentially working from memory using neural networks laid down by many experiences over many years. Knowing this, I realised that the more I could reconstruct an artist's experiences, especially those that were relevant to art-making, the more I could understand the way that his or her neural resources might influence his or her art. In other words, I could go some way to understanding the processes underpinning the phenomenon that Leonardo referred to when he talked of how judgment, the judgment of an artist's moves his hand without him being aware of it. I was getting closer to understanding the mysterious sources of individual inspiration. That at least is the theory. Let's now try and apply it.

There is surely no occasion in the history of art in which individual inspiration was more necessary that the occasion when painting was invented. Steps in this direction must have been taken a thousand times whenever an individual human ancestor made a mark with pigment, and that has been happening certainly since 80,000 years ago. But what happened at the cave of Chauvet in southern France around 30,000 years ago stands out among such episodes. It is remarkable on many grounds. Firstly, it is much older than any other painted representational art, being twice the age of Lascaux. Second, it is extraordinarily lifelike, much more lifelike than Lascaux. Third, it makes use of three quarters perspective, a device not used again until the Greeks 30,000 years later. Fourth, it gives a sense of animals moving through a landscape, something not done again until 25,000 years later, and most remarkably, it captures intelligence – a quality not analysed or celebrated until ancient Greece, and even then not so well represented, I would argue. These qualities make this art exceptional. The fact that there are no precedents for it, no prior sequence of slowly improving sketches, means that it can only have been the product of inspiration. Those that made the images cannot consciously have set out to do so, since images didn't exist before this. Since nobody could have taught them how to make art, they must have invented the activity. Significantly too, since there are no imitations of it for thousands of years, it seems to have excited no conscious response.

Now, what I'm saying here is complete heresy amongst archaeologists. They would say, 'well of course we don't have this evidence, we don't have earlier drawings, but there must have been them', because they simply cannot imagine, using their assumptions about the human mind, that this could happen afresh, like this. Well I will tell you my story about why I think this is the ONLY possible explanation for why this is so. What then were the neural processes that lay behind this extraordinary eruption of human expressive activity? Since it cannot have come from the conscious brain, it must its sources in areas of the brain not accessible to consciousness. Before looking for the areas that are the source for the subject matter of the art, we have first to find the areas of the brain that provoke the painting activity in the first place. In identifying this, we are helped by the art itself. The other occupants of the cave were cave bears, who have left many marks on the cave walls, those parallel vertical scratches, and there are places where those marks have been imitated by humans. In one spot where cave bears had dragged their claws across the surface, humans have later used stone tools to make engravings of mammoths. In another, where cave bears have accidentally touched the cave wall with paws dirty with the mud from the cave floor, humans have later made marks by pressing on the surface, hands covered in pigment. The correlation between the technique and the bear marks is extraordinary. In the past, we would have had to say that the imitation of the bear's was a conscious decision, one that needed further explanation. Today we can say that merely looking at the marks left by the bear's paws would have caused the mirror neurons in humans to fire, so stimulating to use their hands to imitate the bears. The resources for neural mirroring that had helped them when children to imitate their elders and betters, now led them to imitate creatures even bigger and more powerful than their parents.

But would the unconscious neural resources inspire the choice of subject matter? If we survey all the representations in the cave, there is only one common element between them: all the animals possess tools and abilities that humans would have envied, like these horns on a rhinoceros. Members of a delicate new human species, recently arrived from Africa, at a time when much of Europe was covered by an ice sheet, would have looked with admiration at the tools (the claws, teeth, horns, antlers, tusks and fur coats) of the animals they found there. They would have looked with even greater admiration at the intelligent use of their eyes, ears and noses, to find

food and give advance warning of threats. When they noticed this owl's ability, not only to see at night, but to turn its head 180 degrees to look behind it, they were evidently blown away. Because of the principals of neural plasticity, whose applicability to the visual cortex is particularly well understood, having been discovered by Hubel and Wiesel 50 years ago, they would have acquired neural resources that were better and better at perceiving those animals from when they looked at the naturally stained and coloured cave walls, those neural resources would have helped them to see them, in its blotches and fissures, which is why so many images have their starting point in such accidental features. So, that the starting point of this bear, was the sight of these fissures, which activated neural resources which had been used to look at a bear above, from three quarters view, and so on. Since they got such pleasure from observing these features, when their mirror neurons prompted them to touch the imagined creatures, making marks that increased the resemblance, they would have gone on enhancing them until they got the maximum response in feel-good neurochemicals, that is, when the image was as close as possible to the real animal.

But you may say, if these unconscious processes had such dramatic consequences here, why are there no such images in all the other caves with which southern France is so well endowed? The answer is that this cave occupied a site which would have endowed those who lived near it with neural resources unlike those of anyone on the planet. The cave mouth overlooks the river Ardèche, and a mile away the river is crossed by a natural rock arch, the only one in the world over a large river. Since the river runs east-west and in the prevailing severe conditions, animals would have had to migrate north and south in search of food, they are likely to have avoided the risky river crossing and used the bridge as a highway. This would have meant that the humans that lived nearby would have been treated every six months to a wild stampede, looking at the procession like living in a cinema that endlessly showed the same film, would have given them the neural resources for the perception both of the animals and the landscape that were unique on the planet, which is why when their neural networks that had been exposed to the bridge encountered a niche in the cave that had a similar form to the bridge they painted above it a frieze of stampeding animals, including a mammoth, graphically shown commencing its climb. I repeat – there is nothing like this in later prehistoric art. This is completely one-off.

The unique setting inspired the artists of Chauvet both to suggest landscape context and to capture the energies of animals engaged in seasonal migration. But the most extraordinary aspect of these images is the way they are more lifelike than anything except modern wildlife photography and film. You can look at all the art produced over the next 30,000 years and none of it captures either the chaos of random movement, or of purposeful intention, as well as this imagery, except photography. Take the whole history of art, from this moment onwards, and I challenge you to give an example of anything which remotely is as close to this?

You may well say, how can that be? We have always been told that the skill involved in making a lifelike representation is only gained with great effort over a long period under powerful social pressure. Chauvet demonstrates that at least some of the assumptions that underlie that story are simply wrong, especially the assumption of the necessity of consciousness and conscious effort. Conscious effort was certainly important in the vibrant cities of Athens and Florence, but it is hard to see a place for it in an isolated cave in south France, at the moment when modern humans arrived there. There is only one reason why the art of Chauvet is naturalistic, and that is because the people who made it had never seen anything else. They had simply never seen an image. All they had seen were real animals in real situations. By

looking at them with extraordinary intensity they had acquired neural networks of extraordinary richness and complexity, and when they made images they were doing something almost like printing a photograph, which is why their art looks more like wildlife photography that anything produced later, as you see in this comparison of a Chauvet bear with one by Leonardo. I think the Chauvet bear is, just, better. You could say it's more like a Rembrandt drawing. I emphasise the intensity and frequency of their looking, and these properties were reinforced by what they were looking at. No qualities of the animals they were looking at absorbed them more than the intensity of their attention. The most naturalistic images are of extremely sensually aware animals, because neural mirroring ensured that their intense looking was mirrored in the human observers. Neuroscience teaches us that if looking at an animal reinforces the neural networks involved in that looking, looking at animals that are themselves looking intently, will further strengthen that reinforcement. Students at art school are consciously taught to look by their teachers. The artists at Chauvet were unconsciously taught to look by the bears and lions and owls, all these creatures intently looking, as they had been taught to paint and engrave by bears. If, like me, you think that these images are inspired, this is the source of their inspiration, as revealed by neuroscience. An extraordinary level, not of conscious effort, but of attention.

Neuroscience also reveals how that inspiration was lost. Not all the images at Chauvet have star quality. Many seem more routine and the reason is clear. Having suddenly appeared so miraculously, lifelikeness immediately fades away, and for a very simple reason. Those that made the first images were amazed by what they had done, and in that amazement looked at them intently, so bringing decay to the very network that made them possible in the first place. The more they admired their work, the more their networks became degraded, and when they made more images, they were now printing from more schematic networks and so the images they produced became more schematic, as we see in this series of lions and rhinoceroses, each more schematic than the next. Neuroscience explains inspiration, it also explains its decline. Try and find another explanation for this phenomenon, that this art is of supreme naturalism, you never find it again, that's a problem that does need to be explained. But it is important that, following exactly the same principles that I used to explain why it is so naturalistic, it was necessarily going to become degraded, it was necessarily going to become more schematic, because as soon as you look at a work of art, it is less interesting and less complex than reality, and so your networks become more and more schematic.

So, literally ten minutes after the history of art begins, it starts to go downhill. The same process is seen repeatedly in the history of art. Giotto and Michelangelo made supreme images, because they, like the artists at Chauvet, looked more intently than their predecessors at nature, and especially the human body and face. Unlike the artists at Chauvet of course, they did it for conscious reasons as they sought to recapture skills lost since antiquity. But the consequences were similar. By looking more intensely than their contemporaries they acquired much richer neural resources, and it was their possession of those exceptional resources that gave their art its exceptional expressiveness and power. Their art was inspired, and because it was inspired, their successors looked at it in admiration and so acquired neural networks adapted to its perception. It was inevitable that from such networks they would print images that looked more like figures from Giotto and Michelangelo than real people.

An understanding of the principle of neural plasticity thus illuminates one of the most frequent patterns in the history of art – the tendency for inspiration to be succeeded by pale imitation. Michelangelo was one of the first artists to study

anatomy intensely and he was inspired to do so by his older contemporary Leonardo da Vinci, perhaps the most inspired artist in history and certainly the most intensely visually curious and attentive as the thousands of pages of his notebooks testify. There is thus, as has always been recognised, a direct connection, between Leonardo's intense looking and the exceptional quality of his art. As with Michelangelo, his looking was consciously directed, unlike that of the artists of Chauvet, but interestingly, it gave him rare, unconscious sensibilities which were exactly like theirs. So, just how their intense looking at animals has endowed them with resources that were so strong that they could be activated by a stain or a crack in the cave wall, so Leonardo found that too, when he looked at dirty walls, he was seeing what he was thinking about, as he says in his notebooks, and I quote:

> 'If you look at any wall soiled with a variety of stains, or stones with variated patterns, when you have to invent some location, you will there be able to see a resemblance to various landscapes graced with mountains, rivers, rocks, trees, plains, great valleys and hills in many combinations. Or again, you will be able to see various battles and figures darting about, strange looking faces and costumes and the endless variety of things which you can distill into finely rendered forms.'

Now what even Leonardo didn't realise is the ability to see such things in stained walls will be directly proportionate to the frequency and intensity with which you have looked at such things in real life. Leonardo had looked at those things intently and so found inspiration in stained walls. I suspect that most of those who later read his words would have found very little because their neural resources were much weaker.

So my hypothesis, based on an application of my knowledge of neuroscience and the study of the earliest art is that one of the keys to the production of inspired art is looking with great intensity, because it is such looking which leads to the formation of neural networks of the richness necessary to produce works of great power. One test of its validity it to look at the art of the Italian Renaissance as we've just done. But in many ways a much more stringent test is to apply it to living artists because they can tell us what they think of the idea in the first place.

So, I can't resist the temptation to tell you of the reactions to my argument by two contemporary artists. As you'll realise by now, neuroscience empowers me to assume that if we know what an artist has been looking at with exceptional intensity, we will have some idea of the neural resources which may have shaped his work, although the artist concerned will probably be completely unaware of the connection because the process is unconscious. So when I come across a new type of art, I ask myself what might the artists involved have been looking at which lead to the emerge in that form? Using this approach, ten years ago, I asked myself what shared visual experience might have inspired American artists of the 1950s, painters such as Mark Rothko, Barnett Newman and Jasper Johns, make large canvases covered with often featureless paint? The answer I came up with was images of the dustbowl - the 1930s phenomenon which caused the most fertile prairies of the Midwest of America to turn to virtual deserts. This was a traumatic event whose physical and psychological impact was made much worse because it coincided with the Depression and the poverty with which that is associated. This was well documented at the time by cinema newsreels, Life magazine, every newspaper – all were full of these images. So

my suggestion is that people looking at this, as they were eating their cornflakes they saw their parents distressed by images like that – that was an important experience.

Soon afterwards I found myself at a small dinner party, sitting next to Jasper Johns, and as you can imagine I was particularly excited by the opportunity it offered. Because the host was one of the richest men in America and the other guests were the architect Philip Johnson and the painter Roy Lichtenstein, Jasper took me more seriously than he otherwise might, and when towards the end of the meal, after a few glasses of wine, I told him I had been developing a general explanation for abstract expressionism and asked him if I might run it past him, he said sure. And I did. And although he reaction wasn't exactly what I was after, in many ways it was even better. What he said was:

> 'I can't speak for the others, but in my case your explanation may be correct. You see, I come from southern farming stock, and one of my most vivid memories as a child is of my Uncle driving me out one spring to show me his fields. When we arrived, he pointed at the different fields, which were still all virtually empty, and said "Jasper, that one's gonna be good. That one ain't. That one I'm not so sure about." That experience was certainly very important for me.'

From my point of view, it helps to know that this experience would probably have coincided with the dustbowl, when everyone looked at fields with new anxieties. But it also relates particularly to Jasper's own work, both because his paintings look more like dustbowl photographs than those of anyone else, and because he gave them titles like *Flag on Orange Field*. So, if I am to recapture the moment of inspiration for such a work as this, I imagine Jasper in his Manhattan studio in the mid 1950s, staring at the large blank canvas in front of him. Its featureless surface would have reactivated the neural networks so painfully laid down by his experiences of empty fields in the 1930s, both his Uncle's and those of the dustbowl. This meant that, whether he liked it or not, there was a possibility that these networks would have guided his hands as he picked the colours from his palette and applied them, with the result that surface became inflected with all the visceral anxieties of those traumatic years. This is why the work is so powerful. And it's worth pointing out, that the work might have been destroyed or forgotten, had not a wealthy American collector, such as my host that evening, who shared similar neural memories, been so touched by its elegantly bleak surface, that he acquired it and gave it celebrity.

My last artist was not one I chose. Two years ago I was contacted by a Dutch sculptor, Gerard Caris, who's now 84, and he asked me if I would write something for a book about his work. When he sent me some samples, my heart sank. What on earth was I going to say about these mechanical configurations? When I went to his website which talked all about mathematics and claimed he had invented a new style called Pentagonism, and when I went on to read the five books which had already been written about his work which all talked, again, about Plato and geometry, I became even more depressed. Neuroarthistory, I thought, had found its limits. But Caris kept writing. And after about three months of being pestered, I wrote to him again and said that I would look at his work over the weekend and on Monday I'd say yes or no. I needed to know what he'd been looking at, so I went through the CV on his website, hoping for hints on his early visual exposures. What I discovered was more than I could have dreamed. Caris, it seemed, had been trained as an engineer during the war, and for 20 years after it had supervised the construction of oil derricks and other steel fabrications. His last major job had been in 1961 supervising the construction of an

antenna at Andover, Maine, which I promptly Googled. The antenna had been programmed to receive the first TV signals from the Telstar satellite, so I Googled that. His CV also told me that the year before the Andover job, when he was on leave from Saudi Arabia, he had by chance witnessed the planned destruction of Tinguely's *Homage to New York*. This too was found by my search engine. By now my own neural networks had been reconfigured by the same series of exposures that had shaped Caris', and on the Monday it was easy for me to say yes. I now felt like I was living inside his head, and wrote the piece in four days. Here is a summary of my argument.

Caris is a very passionate individual, as you see from this photograph from 1942. He has true mania. He loved his steel constructions and he looked at them intently. His neural networks thus formed, were the ones with which he viewed the Tinguely, and when he looked at the Andover antenna, the Tinguely experiences gave the construction a new interest. The bent line that is the key to the birth of form - that's his first major work of art, which he produced when he was studying art at Berkeley in 1968 - I saw as reflecting his empathy with a signal, sent at the speed of light, from a satellite, when it is bounced onwards from an antenna, an image that must always have absorbed him. And I saw the same bending of a ray coming down from the sky in *Creation of a Pentagon* of 1970 – the work from which all his later ventures in Pentagonism derived. This last work when viewed on its side also has formal properties in common with the structure of the bending machine itself, the Andover antenna, and even more with its prototype at Bell Laboratories, and in both these structures, function requires rectangles to be shunned in favour of polygons. It was not difficult to see his polyhedral net sculptures of 1972 onwards, as spawned from networks shaped by looking at the antenna, and the house he designed in 1981 as shaped by both those and the Telstar satellite itself.

I was almost ready to send off my piece when I had a last thought. I knew the main industry in Caris' home in Maastricht was the Sphinx ceramics factory, source of all lavatories and bidets in the Netherlands. So I Googled that too, and ended up suggesting, very cautiously, that an experience of such products might have neurally influenced his sculptures. Since none of these sources were mentioned anywhere in either his writings or those of his commentators I was certainly nervous when I sent him the text on Friday evening, and the more delighted with the contents of his email back the following morning. He said:

> 'Almost to this day I have had to fight with museum directors to correct their misconception that my work is not an exercise of applied mathematics, nor a mere utility of fivefold symmetry. I was under an intuitive impression that I was obediently following some natural drive and now, with your beautifully written neuroarthistorian view, I am beginning to understand more clearly the origins and the preferences in my visual expression through the knowledge of neural plasticity which you so clearly and powerfully explained.'

And two days later he wrote that he remembered being taken around the Sphinx ceramic factories as a boy by his grandfather who worked there.

With Caris, as with Johns, Michelangelo, Leonardo and the artists of Chauvet, a crucial element in the inspiration for great art was the possession of neural resources of exceptional strength, laid down by looking at particular objects, with a particular intensity.

By now I'm feeling really guilty. I haven't yet spoken about music. So in the remaining minute I want to make a few suggestions on how my neural approach might be applied to painting's sister art. And here, in homage to Steve Jobs, I'd like to show you my MyPod, which I will use in a moment. Perhaps, as I began with the origin of art, I will start with the origin of music, or rather the origin of the main traditions of music in Europe and Sub-Saharan Africa, two of the many traditions of the world. Sub-Saharan African music is most familiar to us in the form of jazz. I'm not a specialist, but I will begin with some generalisations. If they are wrong I will be happy to be corrected. My perception is that European music is highly melodic and favours higher registers, especially for tunes. In its performance, wind and stringed instruments have the dominant roles. In Sub-Saharan music on the other hand, rhythm is more important, with beat having some of the interest that attaches to tune in Europe, and the predominant role being taken by the lower registers. In its performance, percussion instruments are much more important than they are in Europe.

In looking for the inspiration for these differences, that is the unconscious neural processes that underpin them, I am struck by the fact that there is an underlying similarity between the way that humans learn languages and songbirds learn songs. Both learn them from their parents and older members of the species when they are young. The process is unconscious, being driven by neural developments in particular areas of the brain at a specific age. These processes, in both birds and humans, are controlled by DNA. This is why in the absence of speech and song during the relevant periods of the individual's youth, there is liable to be a deficiency in the learner. The process of language learning suggests that the auditory tracts of humans are equipped unconsciously to recognise and pick up patterns in ambient sound, probably because doing so causes the release of pleasure-driven neurochemicals. Now, since one the most obvious sets of patterns, besides those of language, are those of birdsong, humans are likely to acquire a preference for hearing those sounds, and indeed, as they do with language, to imitating them. This would mean that whatever patterns there were in birdsong in the regions in which they were living, they would pick them up.

A prime characteristic of birdsong in the woods and fields of Europe is the song of passerine nest-builders as they seek to impress mates and defend territory. Your gardens are full of them. And a prime characteristic of that song is its extreme tunefulness and its high register. In the rainforests of West Africa by contrast, the area from which jazz originated, such tuneful songs are much less common, probably because they would be drowned out by a myriad insects, also producing sounds in a high register. Many birds make other sounds which are more like pops, crackles and gratings, which are rhythmical and repetitive and typically in a lower register. This means that the overall difference in character of European music and West African music corresponds to the difference in ambient sounds in the two areas. In other words, it is in such ambient sounds that the individuals caught up in these areas found inspiration.

Not that birds were the only source of ambient sound patterns. Other natural phenomenon are associated with repetitive sounds, as I discovered when I was in Cameroon and saw this pod on a market stall. As soon as I picked it up and heard the sound it made I said to myself 'Hey man! This is a syncopated rhythm, this is jazz!' Of course, you can try rattling a pod of European vetch, but you won't hear much and it will be in a much higher register. There are many good ecological reasons why in the tropics such pods are much larger and have a much tougher casing, each of them producing a different sound and a different rhythm, capable of creating wonderful

effects when heard together. Picking up my pod inspired me to make music, and millions of Sub-Saharan Africans had felt that inspiration before me. Just as listening to birdsong in an English field inspired Vaughan Williams' *Lark Ascending* or hearing the beat of a mill wheel on an Austrian stream inspired Schubert's *Die schöne Müllerin***.**

It's also worth noting that there is another reason why low notes are more important in the tropics. Quite simply, the volume of sound produced by all the myriad life forms there - the insects, the birds, the reptiles and animals, both small and large - is much greater than the volume produced by the much less numerous and much smaller life forms in Europe. In such a noisy environment, low notes with their long wave structure make much more impact and travel much further. Amusingly, the same thing is true of one noisy environment in northern Europe – the big city, with its myriad humans and machines, which is why many people, especially young people from Sub-Saharan Africa turn up the bass on the sound system in their cars, to other people's annoyance. It may not be an inspiration you like, but it is an example of inspiration in my terms, that is, an expressive behaviour driven by neural formations of which we are not conscious. Curiously too, birds are similarly inspired because it has been noticed that classic European songbirds who live in modern cities also sing in lower registers than their rural relatives. So the same birds, they also turn up the bass if they're brought up in town.

During this talk, as you will have noticed, I have used inspiration to cover a multitude of behaviours, from the highest creative activity of the painter or musician to the lowest common denominator between humans and animals. Throughout I am using it as the Greeks did, to bring out the importance of behaviours that are beyond conscious control, having their roots in unconscious processes. I would like to return to the Greeks to make my final point about those phenomena to which inspiration is most positively applied - the most complex expressions of the most creative individuals.

The Greeks made the Muses the daughters of Mnemosyne – memory. And there is no better way to indicate the lights that neuroscience can shed on individual inspiration, than to remind ourselves of the depth and complexity of memory. We are used to treating memory as if it were a room in which we store data, and neuroscientists have found such a room in our brains (the hippocampus) but that is not the most important locus of memory for our purposes. To understand the importance of memory, we have to remember every experience we have, every sensation we feel, every movement we make, every emotion or thought we have, is liable to cause changes in the billions of connections between our neurons. Changes that build up layers from our earliest moments, steadily increasing the complexity of resonances that each new experience may evoke. Sometimes we can consciously build and exploit new layers as a pianist does when he repeatedly practices a Beethoven sonata. But most of the time we are completely unconscious of the extent to which our actions, whether falling in love, or painting a picture, are influenced by the infinite connections built up over a lifetime. The mystery of the relation between those profound accumulations and creative expressions will always escape us, but neuroscience can refine our awareness of their unconscious influences. This is why brain scans only enhance the mystery of creative inspiration, or as the Greeks might have called it, true neuromania.

Questions from the audience

Ray Tallis: John, I loved the art history, and obviously I have huge problems with the neuroarthistory. I'm going to give you an example of a specific problem and then a general problem I have. The specific problem is your use of mirror neurons. First of all, the mirror neuron system is somewhat questionable in human beings. We still don't quite know what it amounts to. It's been well established in birds and monkeys, we don't quite know where it lies in human beings, but if the mirror neuron system is well developed in human beings, it presumably is operating all the time. So although you give some reasons why art might have a sudden efflorescence followed by a decay, you give us no reason to understand why people aren't arting all the time, and why in many, many places there wasn't art. The second thing is – of course you can make connections. I had lots of patients who were hypochondriacs and everything added up. Every single tingle, everything. The disease clearly fitted the diagnosis. The only way you can substantiate those connections you make is by making predictions which you can test your theories against and I'm not too sure that you really have made any predictions. Those predictions you seem to have made have actually relied on your reinterpreting some of the data you presented.

John Onians: First of all, it is really important to mention that the degree of a person's response, even when doing the same thing, is different. We are all differently neurally configured. Because, from the first moment we open our eyes, the first movement we make, we will or will not acquire neural connections. If we don't use connections they will fade away and everything depends upon the extent to which the neural mechanisms are exploited. There is a specific question in neurology, and Trimble may have an answer on this, as to exactly which neurons are involved in the mirroring process. We can't run experiments on the human brain which enable us to identify them, because of their invasive nature. We can't run the same experiments on humans that we run on monkeys – that's the only reason we don't know about them. But what we do know about mirror neurons is best inferred from the behaviour. When the mother bends over the cradle and smiles at the child repeatedly, and eventually the child smiles back, that can only be because there is a mirroring process involved, and for my purposes, it's completely irrelevant exactly where it is, or what it is. The point is that you can predict (you talk about the importance of prediction) that if the mother makes a movement that the child will pick it up, if the DNA is saying that the brain should respond to that phenomenon at that time. The most important thing is that we all have different brains and, as I insist, the story that I told about Chauvet, is a story about particular individuals at a particular moment, and I think (in terms of testability) if I formulate a hypothesis, and I look at some paintings of a particular period and I say, I think this is the story behind it, I then ask the artist involved and they say 'I think that's right', to me that is one form of test, I admit not a very good one, he may just be flattered by the comparison, but I don't think he would be, because he's regarded as being a very cerebral artist.

Michael Trimble: It's far too soon in the day to make a decision about that, we have lots of other discussions to go.

Mitch Benn: I'm fascinated by the Chauvet paintings, never seen those before, and it is extraordinary that you get this degree of lifelikeness which is evocative in a way in which nothing was again for 25,000 years. Given that this appears to be the work of a complete tribe, it nonetheless seems reasonable to expect

that one individual would have instigated the work, that at some point there would have been the first person to notice this similarity between the niche and the bridge. It doesn't really contribute anything and there'd be no way of determining this, but have you considered the possibility that that particular person had a kind of autism? I'm not being facetious; there is a form of autism which enables people to produce very, very, very accurate reproductions of very complicated scenes. People have been observed – you can show them the New York skyline from the Staten Island ferry and they can then go inside and draw the whole thing, building for building, window for window. Just a possibility.

J.O: You're absolutely right to get on to autism. As I was writing my argument about Chauvet, indeed all of prehistoric art, I came to the conclusion that language was really of rudimentary development in the prehistoric period, before 10,000 BC, and I wrote a paper in which I was stating this. As I was writing this paper, I discovered that Nicholas Humphreys had written a paper – he'd looked at the art of Chauvet and he said 'I think those people couldn't speak', because if you compare the work, it has a lot in common to the work of Nadia, the famous autistic patient, who made fantastically lively images, until she learned to speak. When she learned to speak in her teens, she lost her artistic talent. So you're absolutely right, but it's not necessarily being autistic, it is lack of speech which is the crucial thing.

M.B: Well you mentioned the almost immediate degradation of the images, the idea that initially it's a painting of life, and then everything else is a painting of a painting, you get that kind of replicative fading. I was just thinking that maybe if you have that one extraordinarily gifted individual, then everything else is painted by people trying to copy him. Just a thought.

Ian Ritchie: Michael, it was you a year ago who spoke at the conference and drew our attention in a passing observation to the ceiling of the Sistine Chapel, and thinking of Michelangelo and his depiction of the left hemisphere of the brain as a background to the Muses, as the middle ground to God himself in the process of creation. To what extent could it be possible, from observation of anatomy, at a very detailed and concentrated level, could he have depicted this, without knowledge of neuroscience at the time? Or would he have had some neuroscientific understanding that could actually equate that to the creativity that one can now connect with that left hemisphere of the brain? Does that come into the art history argument?

M.T: I'll just explain that what I showed was the Sistine Chapel image of God giving knowledge to Adam. God is inside a shape with a number of the Muses and angels, and that shape is totally representative of a cut-through of the human cranium and when you look at it you can even say actually, here is the brain stem and here is the pituitary stalk. That was not my idea but it was in an article that was written by an art historian about that image that I showed. But it looks as if in that painting there is a representation of the human cranium.

J.O: Two facts which one can bring into the debate: whatever your conclusion is, certainly, Michelangelo is the only artist other than Leonardo who did anatomies; he did actually cut open cadavers when he was a young man, so he certainly knew much more about the appearance of elements of the human anatomy. And Leonardo certainly drew cross sections of the brain and the skull. He was really interested in the structure of the brain. What he puts into the brain in fact is a schema which he

acquired from medieval sources, so he doesn't actually make a very good drawing of the interior of the brain, but it is certainly possible that people would have had a sense of the structure of the brain. I think you can be absolutely certain that they wouldn't have been conscious of right and left hemispheres, and of course with people like Leonardo who's left handed – the hemisphere business is something else. All I would say is, it's just possible that, by looking at the brain, they would have some capacity to suggest brain-like shapes in their art.

Question: I just had two quick questions. One was, you talk about the degradation of the paintings and I was wondering is it possible that they were actually sketches, that they were actually practicing? I presume there is some way of dating which came before or after? So what you're calling the degradation of the images in the cave might have been sketches or practices that came before. And my other question is, I was wondering about the Asiatic sounds in music, which again are very different to the European or African, and I just wondered what sort of sounds would be in the environment that you would assume they'd come to make?

J.O: I would certainly hesitate to go into the Asiatic, although what I will say is, I don't know if any of you know about Mongolian breath music? It certainly sounds like almost the only sound they hear, which is the wind. So people who live in a place where the main voice is the wind, end up making music that sounds like the wind. But to go back to Chauvet – the archaeologists make some attempt to decide what is earlier or later – but there is nothing like a sketch for something else. What you get is one very strong image, and then next door to it weaker and weaker and weaker images, as in that image of the rhinoceros. If we go back to that you will see clearly that there is one main image and then that is replicated.