Understanding Rock Art: What Neuroscience Can Add

12

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Abstract

In this chapter, I will make a case that neuroscience can help with the understanding of any art, and that in the context of rock art, with its deep history, it offers particular advantages. Most importantly it can give us new access to the minds of its makers and users, something much needed in the absence of the verbal commentaries associated with most other categories of material. That access, I suggest, can be obtained by using the latest knowledge of the extent to which the formation of the individual brain is affected by the environment to which it is exposed. This knowledge can help not only to reconstruct salient aspects of the neural resources of any individual or group whose material and social environment is sufficiently familiar to us, but also to infer how those resources are likely to have influenced such art-related behaviours as their motor inclinations and visual preferences. When these insights are supported by an understanding of such other newly discovered properties of our brains as its neural plasticity and neural mirroring, we can build up a new understanding of the mental activities behind the similarities and the differences in the way people living at different places and times have marked rock walls. A neural approach also allows us to re-evaluate assumptions about the history of culture that have been taken for granted in the fields of archaeology, anthropology, and art history, such as the pre-eminence of the role of language in the formation of culture and the associated insistence that art is necessarily a symbolic activity. In this way neuroscience can add a new dimension to cultural history.

Keywords

Neuroscience · Phylogenetic · Ontogenetic · Cognitive fluency · Neural plasticity · Neural mirroring · Gestalt psychology · Neurography

12.1 Introduction

There are reasons why the study of rock art can benefit more from the insights of neuroscience than any other category of art. Most other forms of art have some helpful cultural framing, a written or oral commentary, an architectural setting, or a known institutional context, any of which can provide us with understandable ways to make inferences about the minds of their makers and viewers. With most rock art these other sources of contextual information are lacking. In those circumstances neuroscience can play an important role, offering a biologically-based understanding of human mental activity at a time when such creative projects as Francisco Varela's 'neurophenomenology' (Varela 1997) Tim Ingold's 'environmental perception'(Ingold 2022), and Andy Clark's '4E cognition'(Clark 2008) have together created a new sympathy for somatic approaches, and an openness to relational thinking (Watts 2013).

The potential role of neuroscience in rock art research was already envisaged by Desmond Collins, the archaeologist, and myself in our 1978 essay on "The origins of art", which, perhaps for the first time in an archaeological article, already invoked the role of 'neurons' (Collins and Onians 1978,15). But it was the expansion of knowledge of the brain in the subsequent decades driven by new technological developments that was to provide a wider and deeper engagement with neuroscience for art research. This has resulted in such productive extended treatments as those of David Lewis-Williams (2002) in *The Mind in the Cave. Consciousness and the Origins of Art*, Barbara Alpert (2009) in *The Creative Ice Age Brain: Cave Art in the Light of*

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Neuroscience, and Jill Cook (2013) in *Ice Age Art. Arrival of the Modern Mind*. It has also inspired older scholars to elaborate on their earlier biological perspectives, as Ellen Dissanayake (2009) did in her "The artification hypothesis and its relevance to cognitive science, evolutionary aesthetics and neuroaesthetics" and as Robert Bednarik did in "Neuropsychology and Palaeoart" (Bednarik 2008). For others, recent neuroscience research has prompted them to confront more theoretical issues, as Lambros Malafouris (2007) did in his discussion of 'visual thinking' and Whitney Davis' (2011) did in his reflections on 'neurovisuality. By now a larger group of scholars have added original perspectives, from John Halverson (1987) and Derek Hodgson (2003) to Ben Watson (2011) and Ahmed Achrati (2013). I have made my own contributions, such as the more narrowly focussed "Neuroarchaeology and the origins of representation in the Grotte de Chauvet" (Onians 2007) and a more wide-ranging section on "Prehistory: 30,000 to 4,000 BC Art Before literature" in *European Art. A Neuroarthistory* (Onians 2016).

From all this work it is clear that neuroscience can contribute to rock art studies, as by showing how neuropsychology may have led to the ability of hominins to make 'conscious' decisions based on cultural percepts or concepts (Bednarik 2008). However, it is still unclear how great is that contribution, given the resistance to these advances. Some scholars appear to be held back from more expansive insights by assumptions that became ingrained long before knowledge of the brain had reached its current level. They thus continue to assume that the knowledge of /information from modern hunter gatherer societies, such as the Australian Aboriginal people, is core to the understanding of rock art, and that some contemporary practices, such as shamanism, should be central to rock art interpretations. Indeed, such a perspetive is taken for granted by major authorities. As Clottes argues: 'The hypothesis that best accounts for the facts as we currently understand them is that Palaeolithic people had a shamanic religion and created their art within its framework' (Clottes 2008). Once such an assumption of a universal framework is taken for granted it becomes easier for scholars to adopt ready-made explanations without attending to the specifics of each case. Similarly, many have assumed that language always had a dominant role in the formation of culture just because it supplies an easy solution to the problem of understanding how beliefs and practices come to be shared. From these points of view neuroscience is seen only as a supplement to existing approaches, when, if we really want to measure its potential importance, it would be better to treat it as a primary core tool, and the source of completely fresh explanations, as several of the scholars just quoted have done (e.g., Helvenston and Hodgson 2010). This would allow us, for example, to show how aboriginal behaviours and shamanistic practices themselves have origins that are ultimately neural. It would also allow us to recognise that, from the beginning of human culture, the main reason why groups share beliefs and practices is not because they are transmitted to them by words but because the sharing of experiences (including language and words, chants, etc.) has resulted in the formation of shared neural resources, and that it is the sharing of neural resources that predisposes people to similar responses, as shown by the sociobiologist Bedaux (Bedaux 1999). Such a neurally-founded perspective has two clear merits. One is that it creates a new space for enquiry that is not held back by prevalent assumptions. The other is that it puts us in the same position as our ancestors were before culture became consolidated through the formalisation of practices and the authorisation of verbal commentaries. In that situation, lacking the constraints consequent on a dependence on language use and intense socialisation, they will have been much more conscious than we are of the promptings of their nervous systems. If we want to understand them better, it can only help if we too sensitise ourselves to those promptings.

With this goal in mind, and in full awareness of the risks analysed in the 'Workshop on Cognitive Neuroscience/ Neuroscience and the Humanities' which I ran in 2011 at the Center for Advanced Study in the Behavioral Sciences, Stanford, with its then director, the psychologist and neuroscientist, Steve Kosslyn, this paper looks again at some examples of rock art from a range of periods and deploys a range of neuroscientific knowledge, setting out to contribute directly to two important dimensions of enquiry, the phylogenetic and the ontogenetic.

As far as the phylogenetic is concerned, that is the species-wide features of our neural make-up, neuroscience sheds light on the neural resources and associated abilities that we share with all our primate relatives. It also clarifies those that distinguish each hominin genus and species as they appeared, from Australopithecus to *Homo sapiens*. Above all, it makes us aware of the importance of the progressive enlargement of the brain and illuminates the properties that were critical to the well-being of each successive human type. Of particular importance was the brain's plasticity, that is, the way the networks in the individual brain change in largely predictable ways after birth in response to changes in its owner's social and material environment (Doidge 2007). It was this property of the brain that helped our species to adapt to different environments, first in Africa and then beyond, ensuring that the neural equipment of each individual was not just based on a common genetically determined template but adapted to its particular ecology (Grove 2015). Neuroscience thus helps the scholar of rock art to understand the full spectrum of our inclinations, from those that are widely shared, being genetically driven, to those that are purely individual, being the product of one person's experience. In the light of the need to pursue our enquiry on both dimensions we will explore experimentally the successive contributions to the history of art of representatives of three hominin types: Australopithecus, Neanderthal and *Homo sapiens,* each with their own distinctive neural resources.

12.2 Three Hominin Types: Three Types of Art

12.2.1 Australopithecus: The Makapansgat Pebble

When our australopithecine ancestors first made marks and selected materials that later members of the European tradition found visually interesting enough to dignify with the term art, they had little idea of what they were doing or why. In this they were like all the other creatures who have left their traces on the earth's surface. In most cases there was no intention, conscious or otherwise behind their actions, nor did those actions normally evoke a response. An exception to this rule might be the piece of stone known as the Makapansgat Pebble, a reddish dolerite rock eight centimetres in diameter (Fig. 12.1). Because it was found in a cave in South Africa occupied by a hominin member of the genus *Australopithecus* around three million years ago, many miles from its natural source, we can be sure that something about it caught that creature's interest, caused it to pick it up and take it with them. Wilfred Eitzman, the teacher who found the rock in 1925, thought that it attracted that creature because of its resemblance to a human face. We would agree with him, but how are we to understand that response? Eitzman, being familiar with the role of images in later times and very much embedded in his own cultural assumptions, thought it was likely that the rock was a community's 'god'. Raymond Dart, the anatomist to whom he first showed it, being familiar with a wide range of imagery, came to think it might have elicited mirth as a caricature (Dart 1974). Robert Bednarik, whose recent examination showed that the origin of its "markings" is natural, has said that the australopithecine who found it was clearly responding to its 'visual properties'(Bednarik 1998: 6). These interpretations are engaging, but none is supported by any evidence or derived from any theoretical framework. Can neuroscience help us to do more with this intriguing object?

Fig. 12.1 The Makapansgat pebble. (Reproduced with permission from Bednarik (2013))

Neuroscientific findings certainly provide some explicit support for the inference that it was the recognition of a face that elicited the interest in the pebble. Experiments have shown that all primates share a brain area in the fusiform gyrus, the fusiform face area (ffa), that is specialised in the perception of faces (Parr 2011) Indeed, so precisely located is the process involved that we can observe how the alternation in the perception of a face and a vase during exposure to the face/vase illusion is matched by an alternation in the activation of the different brain areas in which the two categories of objects are processed (Andrews et al. 2002; Qiu et al. 2009). This allows us to infer that any of our primate relatives who picked up the pebble would, as they turned it in their hand, have been likely to experience periodic activation of their face-sensitive neurons, leading them to respond to it as they would to a face.

This then provides a new insight into their probable reactions. It has long been understood that a genetically driven human interest in faces has been selected for by evolution because an engagement with faces is critical for our survival. It has been shown by the ethologist Konrad Lorentz (Lorentz 1943) and psychologists working with his ideas (Gardner and Wallach 1965) that our responses to babies' faces are particularly positive, being also genetically driven, because caring for the young is an essential path to the transmission of our genetic material, and it has been argued that this response has had a powerful effect on art (Bedaux 1999). So, given that the face-like form on the pebble is paedomorphic, or child-like, with its bulging forehead and large eyes, it is plausible that its appearance would have encouraged our australopithecines not just to see it as face-like, but to respond to it with parental affection, encouraging them to pick it up and take it with them. If so their behaviour would recall that of young, and especially female, monkeys, who have been seen to 'carry around soft or hairy objects against their chest…just as if they were cuddling a baby' (Byrne 1995),

Nor is this the only dimension to their positive response to the face-likeness of the markings on one side of the pebble. The above noted insights into the brain's workings yielded by one set of experiments have been added to by another.

These are the experiments that have suggested that our pleasure in the perception of a shape, such as a "face" can be correlated with the so-called 'fluency' of the perceptual processes involved (Chenier and Winkielman 2009; Winkielman et al. 2003). This provides, among other things, that the more easily we perceive a shape the greater will be our pleasure in its perception. Given the ease with which we recognise the markings on one side of the pebble as face-like we can be sure of the fluency of the perceptual processes that involves compared to those involved in looking at other pieces of stone in the environment, including the less determinate markings on the pebble's other side, and we can be somewhat confident that that fluency is largely a reflection of the extent to which the neural resources of a typical viewer, whether ancient australopithecine or modern *Homo sapiens*, will necessarily have been shaped by repeated exposure to baby faces. Neuroscience thus sheds light on both our perception of the pebble and our emotional response to it. It not only illuminates the neural processes involved, it also explains their potential "power".

The concept of 'cognitive fluency' can be understood without reference to neuroscience, but the phenomena it captures are a direct product of neural processes. One of the reasons why we experience an increase in cognitive fluency in any perceptual encounter is because the more often and the more intently we have looked at anything the more the contacts between the neural networks involved will strengthen, so making it easier for us to see it. We can confirm the pleasure-giving, or 'hedonic', nature of such perceptions by noting that they are associated with the activation of the zygomaticus, or 'smile' muscle, rather than the corrugator, or 'frown', muscle (Winkielman et al. 2003). The neural pleasure associated with this type of successful perception has its parallels in other perceptual engagements, for example in the responses identified a hundred years ago by the Gestalt psychologists, Wertheimer, Koffka, and Köhler. They noticed the way our perception of phenomena is influenced by their display of particular properties, including good 'figure/ground' differentiation, 'similarity', 'symmetry', 'continuity', 'closure' and 'grouping' (Koffka 1935). Such neurally driven preferences for particular Gestalts have been selected for in our genetic make-up because they help us to see, by facilitating the discrimination of objects in our visual environment. However, a significant corollary of their manifestation is that they render the particular visual experience involved less effortful, so contributing to perceptual fluency. Our vision constantly benefits from the influence of these preferences without our being aware of it. They must have been guiding the hands of humans since they began making, marking and manipulating, in most cases leaving no traces.

12.2.2 Homo Neanderthalensis: The Bruniquel Cave

One place where we may perhaps find the traces of Neanderthal visual preferences is in the cave of Bruniquel in southern France, the site of what is, to us, a mysterious accumulation of broken stalagmites and stalactites, or speleothems, discovered in 1990 (Jaubert et al. 2016) (Fig. 12.2). These speleothems were found in a series of groupings 300 yards from the entrance to the cave system, where they can only have been reached using some sort of lighting. Dating of the associated calcite deposits suggests that they were assembled about 175,000BP, a period at which the only creatures in western Europe capable of constructing them were the Neanderthals. Their agency is evident in the way that the stalagmites have been broken off and arranged so as to constitute two rings, one larger, containing two separate piles, and one smaller. The only other evidence of human activity are the remains of several fires made using animal bones as fuel. There are, as yet, no clues as to the function or cultural context of these assemblages, but given their impressiveness and the absence of analogous dispositions elsewhere they demand some sort of explanation. So, until more is known, we are free to consider a range of scenarios for their creation,

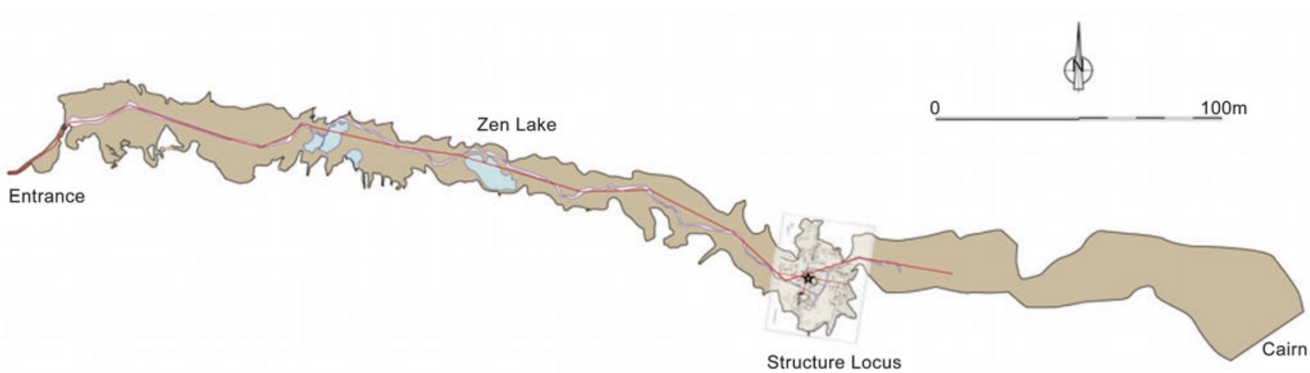

Fig. 12.2 Map of the Bruniquel Cave with indication of the location of the structures. (Reproduced with permission from Sophie Verheyden et al. (2018))

whether more social or more individualistic, more organised or more spontaneous. Whichever path we choose, given our interest in exploring the potential role of neuroscience in explaining such behaviors, it seems difficult to exclude some influences from the general principle of ‘perceptual fluency’ by reference to the visual preferences identified by Gestalt psychologists. We are also more justified in attributing the capacity to perceive Gestalts to our primate predecessors since experiments have shown that monkeys, whose brains are less developed than those of humans, already demonstrate the capacity to see the ‘global’ forms on which Gestalt perception depends (Neiworth et al. 2006).

We cannot know what the cave looked like before it was entered by humans, but it is likely to have presented a scene combining order and disorder, a regular forest of stalactites and stalagmites still standing in the places where they were formed and a confused array of fragments that had been accidentally broken off as a result of the activities of cave bears or earthquakes or other geological processes over millenia. Against this chaotic setting the speleothems will have manifested to Neanderthal viewers such Gestalt properties as ‘similarity’, ‘symmetry’, ‘continuity’ and so on, and an initial pleasure in these attributes may have encouraged some individuals to increase them by moving the pieces around and further breaking them down. If they did, they may well have found themselves unconsciously guided by a pursuit of enhanced perceptual fluency. For example, in the case of the two ring-configurations, we can imagine that if two or three fallen speleothems suggested to viewers an incipient ‘continuity’ they might have strengthened this by moving some elements and adding new ones. Each increase in ‘continuity’ would have been rewarded by the networks that help us in the perception of form, until a circular shape emerged. Similarly, we can envisage that the laying of speleothems in courses within the edges of the rings may be the product of preferences for ‘similarity’ and ‘continuity’, just like the parallel rows of dots in a Gestalt psychologist’s diagram.

Such explanations are necessarily speculative, but they at least meet one of the requirements of any commentary on artistic activity, that it is based on a plausible reconstruction both of the mental processes involved and of the actions to which they led. They also have the added advantage of being able to absorb elements of alternative explanations, such as the suggestion that those rings recalled the layout of shelters or protective enclosures, or that the actions of the individuals involved were controlled by verbal instruction. If we pursue this line of argument, we can suggest that both the large ring and the small ring could be seen to reflect preferences for ‘closure’, while the large pile in the large ring meets the requirements of ‘proximity’ and ‘similarity’. There are also several points at which speleothems have been placed parallel to each other so allowing them to be perceived as possessing ‘symmetry’, while all the groupings, with their strong forms, stand out as ‘figures’ from the relatively featureless ‘ground’ of the cave floor. Perception may thus have begotten composition.

The advantage of a Gestalt approach is that it enables us to account for how such configurations could come into being without any need for planning or co-ordination. If so, there could be some analogy with the behaviour Köhler observed in a chimpanzee who was able spontaneously and without trial and error, to pile up boxes to reach food (Köhler 1925). Gestalt principles can also be invoked when explaining another feature of the configurations at Bruniquel, that is the relative standardisation of the stalagmite fragments, which average 34.4cms in length for the larger ring and 29.5 for the smaller (Jaubert et al. 2016). It is difficult to credit a Neanderthal with a rational explanation for this conformity, but it can be understood as gratifying simply in terms of cognitive fluency. We cannot conceive of why Neanderthals might have consciously measured things, but we can at least assume or suggest that enjoyment of the pleasure of perceptual fluency will have given them an unconscious preference for such ‘similarity’. So, if one or more individuals found some speleothems that had been broken, whether by seismic events, or by cave-bear activity, and sensed some emergent order in them, they may have been tempted to increase that order by moving pieces so as to enhance their Gestalt properties. Whatever the number of the individuals involved, or the nature of the relationship between them, their motivations to complete the structures may have derived above all from the pleasure associated with an increase in the perceptual fluency associated with their viewing.

12.2.3 *Homo sapiens*: The Cave of Chauvet/ Grotte Pont d’Arc

At Bruniquel, we suggested that neuroscience can add something to our understanding of the stalagmite assemblages by allowing us to invoke universal properties of the human nervous system. Where neuroscience comes into its own, however, is when we can use a knowledge of the particular neural formation of an individual or a group to explain particular aspects of artistic behaviour at a specific place and time, especially when these cannot be explained in any other way. A good test case is the art found in the Chauvet cave in the Rhone region of southern France, officially known as the Grotte Pont d’Arc after the nearby rock arch over the Ardeche river (Figs. 12.3, 12.4, and 12.5). At any period in the Palaeolithic the imagery here would be extraordinary both for its quality in our eyes and its quantity. It is even more remarkable now that it is widely accepted, after much controversy and objection (Pettitt and Bahn 2015), that it is exceptionally early in the Upper Paleolithic sequence, being now reliably dated to two phases in the Aurignacian period,

Fig. 12.3 Bear painting in the Chauvet cave. (Hulton Fine Art Collection via Heritage Images/Getty Images)

Fig. 12.4 A panther marked by dots above marks left by a clay-covered bear paw, Chauvet Cave. J. Clottes/Ministère de la Culture

Fig. 12.5 Lionesses hunting, Chauvet Cave. (Bonnafe Jean-Paul via Getty Images)

36 to 35,000BP and c.30,000BP (Sadier et al. 2012). The limitations of currently available approaches to the interpretation of this art are evident from the first publications of the site (Chauvet et al. 1996 and Clottes et al. 2003). These are meticulous in their descriptions of the topography of the cave, and the identification of the techniques and subjects of the paintings and engravings it contains, but the authors are understandably hesitant when it comes to addressing the ensemble's many features that are so original as to call for some sort of explanation.

12.3 Why Is There Such Art at Chauvet? The Role of Neural Mirroring

The most obvious of these is the number and range of the images. Although there is some early art at other sites, like the paintings recently discovered in Sulawesi, Indonesia, they are very limited both in number and in subject matter. At Chauvet we find many different animals and many different techniques. No known palaeolithic site can rival it, although there are some, such as Lascaux or Altamira, which come close in their richness. What was it that inspired this exceptional expressive outburst? One factor is suggested by a widespread feature of the imagery, the use of techniques that are possibly influenced by the actions of earlier occupants of the cave, cave bears. There are several places where humans have made their engravings with hard implements close to places where bears have first marked the wall with their claws. There is also one where a human has made a painted image of a panther near where a bear has marked the wall with muddy paw prints, and, in this case, there is an even closer resemblance between the two activities because the shape of the panther has been built up by repeatedly pressing pigment-covered hands to the wall (Fig. 12.4). In all these cases one might suggest that the humans are imitating the bears in their clawing and pawing of the walls. Such, a relationship between humans and bears was first identified in later Palaeolithic art a hundred years ago by the psychologist G.H.Luquet (Luquet 1930). Today, we can even perhaps explain it in terms of what is called 'neural mirroring'.

Neural mirroring has many dimensions (Rizzolatti and Craighero 2004) (Freedberg and Gallese 2007). One is the way the neurons of our motor networks are liable to be activated just by watching the actions of others. Such mirroring was first discovered when it was observed that a class of premotor neurons in a monkey's brain that normally control its hand could also be stimulated just by seeing the hand of another monkey, or a human, making a similar movement. Indeed, they might fire just because the monkey heard a sound that was caused by another monkey's hand movement, such as the cracking of a nut. Later, neural mirroring has been observed more widely, especially in the higher primates. Indeed, it is clear that it is one of the main ways we all learn skills from our elders and betters. Knowing of the existence of this mechanism and knowing that it could be triggered merely by the sound of an action that involved a particular movement, we can easily see how the sight of the marks left by the bears might have caused the mirroring neurons in the brains of humans to fire, so causing them to initiate engraving and colouring activities of their own. Such imitation is all the more likely to have happened if we reflect that members of a human population only relatively recently arrived from Africa would have looked with envy and admiration at the bears, who were bigger, stronger, and in all ways physically better equipped than they to survive in a cold and inhospitable Europe. Given human envy, as well as fear and apprehension for the bears, we can well hypothesize that the bear paw and claw marks, which were everywhere, not just on the walls of the cave, but also on the floor, might have evoked a wave of similar human marking. Such neural mirroring would also explain another puzzling feature in the cave, the repeated use of handprints, finger marks and hand silhouettes. The mere sight of the marks left by the bears' paws could well have activated the neural resources governing the analogous movements of human hands. Given the depth of the respect for animals, and especially bears, evident in the cave's paintings, and the witness to the mirroring response provided by the juxtapositions of claw scratches and engravings, it is not difficult to see the numbers of dots, prints and silhouettes as testimony to the overwhelming power of the animal examples over human neural resources.

12.4 Why the Life-Likeness? Neural plasticity and Admiration

Another aspect of the art of Chauvet which asks for some explanation is the exceptional vitality and life-likeness of many of the painted and drawn animals, especially a bear in the Hall of the Bears (Fig. 12.4). Most striking is the angle of view, a three-quarter perspective from above. This, combined with the exploitation of the natural relief of the cave wall, gives a powerful impression of a three-dimensional figure moving through space, very different from the schematic outline silhouette used in much other Palaeolithic art. In western art history we will not witness such perspective again until Greece around 400 BC. Less obvious, but equally important, is the capturing of what might be taken as the bear's intelligence and alertness as it moves purposefully forward guided by its senses. Nothing like this is found in later Palaeolithic art, and it is hard to rival it in later European traditions. Indeed, it is only matched by another Chauvet image of two lions (Fig. 12.5). There is nothing comparable to this until modern wildlife photography (Fig. 12.6). To capture such lifelikeness the artist, or artists, involved must have possessed exceptionally rich neural resources for the perception of these animals and neuroscience teaches us that those

Fig. 12.6 Lioness stalking, Masai Mara, Kenya. (Peter Blackwell/naturepl.com)

resources can only have been built up by intense and repeated observation owing to the plasticity of the neural networks involved.

Neuroscience provides that each experience we have, sensory, motor, emotional and so on, depends on the activation of particular neural networks and plasaticity provides that each time we repeat that experience the connections in those networks are liable to be strengthened and their function improved by reinforced insulation. In the field of vision such neural enhancement makes us better at perceiving the object concerned and even gives us a preference for looking at anything that shares its salient features. Today we are familiar with the benefits of such plasticity as we acquire enriched neural resources of many kinds by study and practice driven by social pressures and structured education. The impact of such neural enhancement at the level of the individual can also now be directly measured by experiment, as in the calculation of the enlargement of the posterior hippocampus, the brain's topographic memory area, in London taxi drivers who were successful in their training in the city's layout (Woolett and Maguire 2011).

12.5 Neurography?

What was it that caused what we interpret as an exceptional enhancement of the visual cortex of the artist or artists who happened to use this cave? At a time when they were members of a vulnerable population thinly spread in a challenging environment there can be no question of the social pressure and institutional formation with which we are familiar in later urban cultures. What else might have caused them to build up neural resources for the perception of animals perhaps richer than those of anyone on the planet? When looking for an explanation of such astonishingly fresh images we can hardly refer to TEK, traditional ecological knowledge.

Everything about them suggests not traditional knowledge but first-hand observation. We cannot know what drove that observation, but the content of the images is highly suggestive. What sets them apart, not only from other palaeolithic art, but most later art, is the artist' or artists' documentation not of the strength and savagery of their animal subjects, but their intelligent alertness, for which the artists' admiration is palpable. And this admiration will have had neurological consequences, whose impact we can invoke when developing our explanations, allowing us to suggest that the image-makers were inspired by their admiration for the bear, which they might otherwise only have seen as dangerous. In this view, admiration could have caused individuals to look at bears so intently that they built up exceptional neural resources for their perception. It was only because of the impact of such visual concentration on their neural formation that they were able to produce an image whose accuracy would be unrivalled until the appearance of photography, which is why I am tempted to call the naturalistic art of Chauvet neurography. It is, after all, the product of the action of neurons, as photography is the product of the action of light.

My claim for the role of admiration in the background to the making of this bear image can be expanded by another comparison, this time between the Chauvet bear and one drawn by Leonardo da Vinci (Fig. 12.7). Da Vinci is thought today to be an artist who made strong images because he knew how to look, but his bear, for all its anatomical detail, comes over as weak. He had clearly examined the bear carefully, but evidently not often enough or, I would suggest, not with enough admiration. So the bear that Leonardo drew at the height of his artistic powers can be seen as a limp creature compared to the charismatic beast at Chauvet. The beneficial impact of admiration in stimulating 'powerful' imagery is well brought out in a paper entitled 'Neural Correlates of Admiration and Compassion', which points out that admiration for someone else's physical skill activates our own muscular skeletal networks and concludes that the experience of that emotion produces a sense of heightened self-awareness that 'incites our own desire to be. . . skillful' (Immordino-Yang et al. 2009). It is as if the painter of the bear has so admired the intelligence of its movements that they have wanted to rival its skillfulness in their own handiwork. That is why most people find the Chauvet artist's bear to be much more impressive than Leonardo's.

Fig. 12.7 Leonardo da Vinci, *Bear walking*, early to mid 1480's, metalpoint on pink-light brown paper, 10.3 x 13.4 cm New York, The Metropolitan Museum of Art, Robert Lehman Collection, 1975. www.metmuseum.org

12.6 Admiration and the Reward System

Neural plasticity laid down the rich neural resources needed to make such a painting, but the drive to execute it probably came from another neural process, neural reward, of which we have just seen an example. When we look at anything we experience as potentially beneficial to us, a potential sexual partner, a desirable food, or an attractive landscape, we are apt to experience a release of the neurochemical dopamine in our nucleus accumbens, the brain's crucial interface between motivation and action (Zeki 2009). This gives us pleasure, and this is significant, because dopamine contributes to the laying down of memories, so that, when the opportunity for a similar experience presents itself, we are neurochemically encouraged to repeat it (Molina-Luna et al. 2009). We are used to writing a social history of later art based on our understanding of the role of social rewards in developed cultures (Baxandall 1972). We can now propose a much more wide-ranging neural history of art based on our understanding of rewards which are neural. If we are right in saying that the individual who painted our bear admired it greatly, it follows that they must have derived considerable pleasure from the appreciation of its many natural assets. This means that the sight of the bear will have triggered a release of dopamine in their reward mechanism. Significantly, though, they will have got an even bigger 'hit' from their painting of it. When they looked at that, they will have been admiring not just the resources of the bear, but their own skill.

12.7 Why Here? The Rock Arch

Neuroscience can help us to answer many questions about the unique features of the art of Chauvet, but one remains, 'why do we find them only there?' All the points made so far would apply to many other humans in many other caves.

Why, then, did they not – as far as we know today – produce anything remotely comparable? Was there something about the site of Chauvet that uniquely promoted the intense observation of animals which neuroscience suggests was the key to their extraordinary properties? Fortunately, there is an obvious answer. The cave is sited at a point where the Ardèche river running from west to east is spanned by a great rock arch, a rare conjunction that had a particular significance in the ice age. In those climatic conditions the herbivores on which Palaeolithic humans fed would have been forced to migrate, together with the carnivores who preyed on them, northwards in spring and southwards in autumn, and they would have found in the rock bridge a safe passage across the great natural obstacle. The humans who lived there would thus have enjoyed exceptional opportunities to watch animals, and they would also have had an exceptional motivation to do so, since the severity of the climate would have caused the comparatively delicate hairless humans, originally adapted to tropical Africa, to look with envy at the animals' superior equipment, the teeth and tusks, the claws and horns, the warm furs and, above all, the skills at exploiting the hostile environment of the creatures with whom they shared it.

The cave's unique situation overlooking the rock arch gave those who used it an unrivalled ring-side seat of one of the great spectacles of nature, the seasonal migration of all sorts of animals, and we can sense the consequence of this rare exposure in the expansive painting around the great niche in the End Chamber. It seems that looking at the animals crossing the arch had so strengthened the neural networks of viewers that, when they came upon the niche, its shape activated the networks laid down by exposure to the arch, and this in turn reactivated the networks shaped by exposure to the stream of animals passing over it. So persistent was the visual memory of this scene that they were provoked to effectively recreate it. This hypothesis, that the painting on the wall of the End Chamber reflects a visual memory of migration over the arch helps us to understand many of its unique features. It explains why the composition reads as a sweeping procession of animals moving in one direction from right to left, something unknown in palaeolithic art, and also why the species are so mixed, something that only happens under stress. It also helps us to appreciate such details as the elephant to the right of the niche who appears to be climbing uphill.

We cannot know the neural processes that led to some individuals turning that imagined scene into a representation, but it is likely that because getting to know the animals by watching them generated a neurochemical reward, they would have experienced a similar reward when they imagined them on the cave wall and even more as they made them visible again in paint. Probably the process would have been encouraged by marks on the surface of the rock which already matched a particular neural memory, as so often happens in prehistoric art. An eloquent example is the painting of our bear (Fig. 12.3). There the unusual perspective seems to have been triggered by the way some lines in the cave wall matched the visual memory of the left forepaw of a bear seen from above in ¾ view. The acuteness of the memory will have been a consequence of the bear's viewer having been particularly impressed by the animal's exceptional alertness and mobility, just as the acuteness of the memory of the individual or individuals who painted the animals around the niche may have been due to their having been impressed by the purposiveness of their migration.

A neural approach thus helps to explain the sudden appearance of naturalistic representation, and, significantly, it also explains why it dies out and is never seen again. Indeed, it does not just help us to explain the absence of comparable work later, it predicts it. The core argument in relation to the extreme naturalism of some images at Chauvet is that because the individuals who made them had looked with exceptional intensity at the animals represented they had acquired exceptionally rich neural networks for their perception. What they could not know is that this achievement of naturalism ensured that it would never be repeated. The representations were so good that their makers would have got a strong neurochemical reward from looking at them. They would have admired their painting as they had once admired the live animal itself, and that led them to get more rewards by making more images. The downside to this sequence was that the new images were made with networks now degraded by looking intently not at a live animal, but at a representation, which was inevitably more schematic. So the second image would have lacked the lifelikeness of the first. Indeed, we can see this happening already with our original bear painting. Just behind that image the artist has made another incomplete version from an identical perspective, and in front he has made yet another. We thus have two copies of the original, each weaker than its predecessor, and there is yet another weak copy in the adjoining gallery. Looking at the original masterpiece has made it impossible for even its maker to repeat it, because exposure to the image had degraded the networks once laid down by looking at a real animal. Other images in the cave tell a similar story, such as the series of rhinoceros to the left of the niche and the lions to the right, each more stereotyped than its predecessor. Again and again at Chauvet we see images being repeated and becoming more schematic. We have always been told that images start out schematic and become more naturalistic, but, whatever the relevance of that account to later phases of art, it does not apply at Chauvet. The first art is much the most naturalistic because it was made by people who had only been exposed to real animals. Later art is less naturalistic because it was made by people who had had the disadvantage of also having been exposed to representations of them.

They had of course also been exposed to real animals, but their exposure to painted animals would have had a greater neural impact because pride in their handiwork would have ensured that it brought a greater neurochemical reward, especially if they themselves were the makers, as appears to have been the case with the bear.

12.8 The Mind in the Skull

Neuroscience adds enormously to our understanding of the art at Chauvet. Most obviously it provides answers to the crucial questions, which are not even posed by scholars who rely on other approaches, presumably because they have no answers to them, illustrating the truth of the ancient observation that if you cant explain something you are less likely to see it. Among those questions are: why is there nothing comparable at other sites? why is Chauvet so early? why does it portray so many animals? why are some of these portrayals so fresh, original and lifelike, while the majority consist of copies and schematic derivatives/ and why is there a particular concentration on sensory alertness and intelligence? Neuroscience would suggest that the answers to all these questions depend on a recognition that at Chauvet a few members of the new species of *Homo sapiens* recently arrived from Africa and finding themselves in a hostile climate to which they were not adapted, taking advantage of the opportunity offered by the rock bridge across the Ardèche, looked with envy and admiration on the members of rival species who seemed better equipped from birth, both physically and mentally.

This last claim, that the humans at Chauvet were particularly impressed by the minds of their rivals, will strike many as surprising. After all we are used to thinking that the mind only became a subject of reflection with the ancient Greeks, as when Plato in the *Timaeus* materialised it in the brain inside the head. We are not used to crediting the inarticulate inhabitants of ice age Europe with such philosophical concerns, but Chauvet suggests we may have underestimated them. If admiration for the intelligence of bears and lions caused some individuals to look at them so intently that they could capture that intelligence in an image we can see how such a concentration might have left its trace elsewhere in the cave. It would, for example, provide a context for the concentration on the head, not just in the bear but in many other paintings, such as the rows of lions to the right of the niche in the End Gallery and the aurochs' and horses' heads on the left of the Panel of the Horses, or the frontal bison and the engraving of an owl, seen from the back, but with the face turned to the front. But the most remarkable celebration of the head at Chauvet is the cave bear skull placed on a rock in the Skull Chamber, where it is surrounded by forty more on the cave floor, some perhaps lying where the animal died, but others perhaps having been collected from elsewhere. Cave bear bones are found in many caves, but never with this emphasis on the skull. If we reflect that the painters of the bear and the lions seem to have sensed that their most remarkable resources resided in those creatures' heads, we can see how others might have shared their perception, so that their insight could have become communal. There may have been some verbal commentary, but it is not necessary for a neural explanation. All that was needed for the original insight was for one or more humans to have been so impressed by the head's role as the seat of sensory alertness and mental focus that they were moved to give prominence to its bony residue after death, the skull.

Such a special treatment of a body part is not without parallels in nature. Other animals pay differential attention to particular bones and organs. Elephants give attention to the skulls of conspecifics, visiting and touching those of dead group members, and many predators kill by consistently clamping either the muzzle or the throat of their prey, as if it is the location of an on/off switch. Differential treatment is also paralleled in later human history, as at the site of one of the first towns, Neolithic Catal Huyuk in Turkey, where the skulls of both oxen and humans were the focus of ritual attention. There it is a symptom of a new trend in the emergence of religion, one manifested in many different ways at other Epipalaeolithic and Neolithic sites. In each case, I would argue, such behaviours can be better understood if we relate their specificities, as revealed by archaeologists, to the principles of neuroscience, as I have tried to do here.

12.9 Conclusion

Before archaeologists and anthropologists had access to neuroscience it was easy for them to assume that cultural history developed in a series of necessary stages, because, although they could follow the social and behavioural transformations involved and had a good grasp of their general manifestations, they had no understanding of the detailed mechanisms underlying change. Today, neuroscience, by giving insights into those mechanisms, allows us to write a more fine-grained account, explaining for the first time why particular changes in particular fields happened at particular places and particular times.

This transforms our relation to our research materials, as the development of my thought in this article demonstrates. The tools that were available before I studied neuroscience, which were primarily social, didn't allow myself, or anybody else, to explain all the myriad features that make Chauvet unique. They didn't even allow me or anyone else to see them. Once I learned about neural plasticity and became aware that the resources an artist uses when making a representation must have been shaped by what they have earlier been looking at with intensity, it became obvious that the individuals who painted the bear and the lions must have been looking in a different way than the makers of other Palaeolithic representations. Most telling was the realisation that at Chauvet I was watching a cascade of reprised activities. The subjects of their paintings were individual animals who were looking with special intensity, and they, the artists, were doing the same, this activity in both cases being driven by particular neural mechanisms, those that cause mirroring and those triggered by admiration.

It is only a small further step to realise that I too figured in this cascade. I was reprising the intense looking of my subjects, just as they reprised the intense looking of theirs, the bear and the lions, being driven by the same mechanisms. It was humbling to realise that, although I, as an art historian, had been trained to look, I looked much more closely at the art of Chauvet after I had received a lesson in looking both from the Chauvet artists and from their subjects. Without realising it, I had fulfilled the project I outlined at the beginning, when I said that "If we want to understand" the makers of rock art better, it can only help if we sensitise ourselves to what must have been "the promptings of their nervous systems." If I am right, anyone who looks closely at the paintings of the bear and the lions knowing about neural mirroring and the neural correlates of admiration, will end up looking more intelligently.

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