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Art, the Visual Imagination and Neuroscience:
the Chauvet Cave, *Mona Lisa*'s smile and Michelangelo's *terribilitá*

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Abstract: This paper considers several types of imagination relevant to art

historical enquiry. These are exemplified in artistic expressions ranging

from palaeolithic paintings in the Chauvet Cave, to drawings, sculptures

and buildings designed by Michelangelo and drawings and paintings by

Leonardo, and are related to recent neuroscientific discoveries. From this

it emerges that important types of imagination cannot be understood

without an appreciation of the neural processes that underlie them and

especially without an acknowledgement of the importance of

neurochemistry.

Keywords: Imagination, art, memory, admiration, fear, amygdala, neural

plasticity, neurochemistry

Introduction

As an art historian I have often had to use my imagination, but

never so much as when I started to use neuroscience to solve art historical

problems, especially those concerned with the visual imagination itself.

After all, how does one relate the hard facts about the brain, which are the

materials of science, to the subtler products of the mind which are the materials of the humanities, especially in this elusive area?

The problem of how to apply the findings of basic neuroscience to other areas is now widely studied. Indeed, when the application is to clinical areas, it has led to the emergence of a distinct discipline of 'translational neuroscience', designed to ensure that the application is responsible and productive. The application of neuroscience to the humanities should share similar aspirations, but can never be so rigorous. One way of describing its difference from 'translational neuroscience' as a disciplinary framework is precisely the greater role it accords to the imagination.

In the field of art a particularly well-founded application of neuroscience is provided by the collaboration between the art historian, David Freedberg, and the neuroscientist, Vittorio Gallese (Freedberg and Gallese, 2007). Their exploitation of a knowledge of 'mirror neurons' has allowed them to imaginatively reconstruct viewer responses to art with a new precision. Others have attempted such imaginative reconstructions of response without the aid of neuroscience using other frameworks. Horst Bredekamp has used the concept of the *Bildakt* (Bredekamp 2010), according to which images have a life of their own, one which is capable of acting on the viewer. Michael Fried, too, has been concerned with the life of images, appealing to 'absorption' as a

quality that particularly engages viewers, as in his analysis of our response to back views (Fried 2001). The power of images is also addressed by W.J.T.Mitchell (Mitchell 2005) when he tells how we should consider pictures to be living things, and Caroline van Eck (van Eck, 2015) when she shows how statues have often been felt to have agency. The imaginative arguments of all these scholars can be supported by a knowledge of neuroscience's demonstration that when we look at something or somebody all our body is likely to be involved. The need to understand the imagination of both the artist and the viewer has never been more urgent, and has again and again required art historians to activate their own.

. **Varieties of the artistic imagination and their neural correlates**

What do we mean by the artistic imagination? It has many aspects, and one is well brought out by Leonardo's observation that a painter can find inspiration in a stained wall: 'A man may seek out in such a stain heads of men, various animals, battles, rocks, seas, clouds, woods and other similar things' (Kemp 1989, 201). In what were only chance marks Leonardo imagined he saw objects, and we can see what he meant if we look at his drawings, some of which look just like a confusing whirl of lines. Leonardo's experience has a long history, going back to the very first art. Many prehistoric paintings have their origins precisely in such

stains on cave walls. Some of the most remarkable examples are the very

earliest in the cave of Chauvet from 30,000 years ago, where again and

again images have their starting point in a crack or a discoloration. This

painting of a bear **(fig 1),** for instance, was inspired by the

correspondence between some marks on the cave wall and the outline of

the forepaw of a bear seen from a ¾ view angle from above.

What explanation does neuroscience suggest for such an intense

imagination of specific images? The basic process is certainly the same

as that involved in all vision.   As Keiji Tanaka and others have shown,

because of neural plasticity each time we look at something the

connections between the neurons involved multiply and strengthen,

making it easier and easier for us for us to see that particular object,

which the brain recognizes as important to us. It was because those who

made the images at Chauvet had given frequent and intense attention to

creatures such as highly alert bears and powerfully focused lions that

their neural networks helped them to see them in the shifting surfaces of

the cave's walls. It wasn't that they were consciously imagining those

animals, just that their brains were, without them knowing it, helping

them to find those creatures they had looked at most intently and

repeatedly.

The reason for such intense looking is illuminated by a paper on

the 'Neural correlates of admiration and compassion' by members of

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Antonio Damasio's team at USC. Comparing the different neural responses to distinct scenarios they found that they all involved the Default Mode Network, DMN, that is the set of interconnected areas of the brain recently identified as consistently active when the brain is not engaged in a particular task. This Default Mode Network includes the precuneus, the posterior cingulate cortex and retrosplenal regions, which together form the posteromedial cortices, and other regions associated with personal biography, self-awareness, day dreaming, remembering the past and anticipating the future. It is as if in the Default Mode these regions are mapping our needs and so preparing us for challenges that are to come. This explains why Damasio's team found that admiration for a particular physical attainment activated specific somatosensory and musculoskeletal areas. As they say, this suggests that admiration for another's skill may 'incite our own desire to be skillful' (Immordino-Yang et al. 2009, 8021). Applying that observation to the images from Chauvet we can note that there was nothing that our Ice Age forbears would have admired more than the hunting skills of bears and lions. It was the intense looking associated with such admiration that resulted in the laying down of the rich networks for their perception that caused them to imagine their shapes in the cave's stained walls. It is because they had never looked at pictures of bears or lions, only at real animals whose hunting skills they admired, that they were able to capture them so

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effectively, as in a photograph. Indeed, to bring out the extent to which their naturalism is due to neural formation, we can call them 'neurographs'.

Admiration is one emotion that causes intense looking. Fear is another, and one that in particular circumstances is especially liable to activate the imagination. We all remember walking in the woods and discovering how the silhouette of a tree stump which, during the day, would hardly attract our attention can at night suggest a dangerous human or animal. The sensation of seeing a non-existent creature in the dusk is similar to the experience of seeing an image in a dirty wall, but it is driven by highly specific neural processes, an environmental cue activating the amygdala and hypothalamus and eliciting the release of a neurochemical such as noradrenaline, causing the body to prepare for 'fight or flight' reaction, to either engage with the danger or avoid it (Tanaka, M, Yoshida M, Emoto H, Ishii H. 2000). In such circumstances reactions vary from person to person, and it has been known for some time that in an uncertain situation aggressive individuals are more likely to suppress higher mental activity and to manifest behaviours driven by the amygdala (Dodge 1980). This often involves some exaggeration of the imagined threat, and the role of the imagination in this context is typical, as explained by Garfinkel and Critchley in a recent survey of 'the neural correlates of fear' in *Neuroscience and Neuroeconomics*: 'Potential

threats are inferred from partial information as the cost of missing a real threat may be catastrophic (Critchley and Garfinkel 2014). The neuroscience of fear is one of the keys to understanding how our imagination is liable to erroneously complete an incomplete shape.

This over-riding creative power of fear is manifested in a surprising place, a drawing by Michelangelo in the Casa Buonarroti from the 1520's (**fig.2**). Michelangelo began the sheet in conscious control, writing a commentary on his latest project, the New Sacristy of S.Lorenzo, Florence, intended to house the tombs of members of the Medici family, and drawing some of its columnar elements. This routine activity is, however, interrupted on one of the bases where architectural mouldings become transformed into the profile of a head. Nor is the head one that the artist could ever have set out to draw in this context. Rather its combination of turban and aquiline nose identify it as a Turkish or Muslim type, one feared and hated by everyone in Christian Europe at the time. Michelangelo's invention is inspired not by conscious intention, but unconscious fear. In the aftermath of the Fall of Constantinople 1453, at a time when Turkish vessels were harrying the coast of Italy, all Italians would have dreaded the appearance of a turbaned head. Michelangelo had obviously not seen many Turks, but he knew what they looked like from representations such as Bertoldo's medal of Sultan Mehmet and must often have imagined them. Since neuroscience teaches us that the

visual imagination uses the same areas of the visual brain as normal vision, neural plasticity would have ensured that the networks involved in that imagining would have become ever stronger as the threat persisted, leading him to complete what Garfinkel and Critchley would have called the 'partial information' of the rounded torus moulding by adding an 'oriental' hooked nose and an angular tooth-like element below it, both threatening shapes. The great Michelangelo's conscious decision to design a relatively banal architectural detail has been derailed by the release of noradrenaline in his amygdala.

Nor is this the only testimony to Michelangelo's mood of anxiety when working on the sheet. Lines at the top elaborate on the meaning of the Sacristy's sculptures, telling how Duke Giuliano has closed the eyes of the statue of Night to avenge himself on time for having ended his life. It was not strange for Michelangelo to associate the Medici with the concept of vengeance. There had for a hundred years been a vendetta between their family and supporters of the Florentine Republic, and the artist himself had been involved on both sides, first working for them in the 1490's and then, after their fall from power, creating the aggressive *David* in front of the seat of Republican government in 1504 to intimidate them, before changing sides again following the election of the Medici Pope Leo X in 1514 and the return of the family to Florence. The New Sacristy was only one of a whole group of powerful monuments

Michelangelo created around their family church, S. Lorenzo. As a famous enemy of the Medici he was certainly frightened of them and we know that Leo felt the same way about him. The return of the Medici filled Michelangelo with fear just as nightfall in the woods fills an ordinary person. If fear of the Medici was compounded with fear of the Turk it is easy to see how in the 1520s his brain may have been frequently awash with noradrenaline making it easy for him both to write of a Medicean vendetta and to imagine a moulding turning into a Turk.

Michelangelo never carved that moulding, but he did design another in the Sacristy which reflects a similar fear-driven imaginative transformation of a conventional detail. This is in the row of masks inserted as a frieze behind the tombs (**fig.3)** These are evidently the product of a process exactly analogous to that which elicited the face from the column base. Even as Michelangelo introduced two standard mouldings at the top of the frieze, a classic so-called egg-and-dart, an alternation of rounded and pointed forms, with tooth-like dentils, he found himself inventing a new doppelganger below, in which aggressive faces, their mouths filled with large teeth, alternate with arrowheads equipped with threateningly angular points and barbs. As with the Casa Buonarroti drawing, it is difficult to explain the way an innocent moulding becomes terrifyingly anthropomorphic without reference to the function of the amygdala as a driver of the imagination.

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The same is true of the unprecedented shape of the fortifications Michelangelo designed to protect his city from the Medici after they had been thrown out in 1527 (**fig. 4).** The layout of his new bulwarks forcefully elaborate on the aggressive curved and angular forms in the frieze of masks and arrowheads. An expressive weapon originally intended in the Sacristy to intimidate the Medici's enemies was now turned back on them and their supporters, providing the latest example of the terribilitá, 'terrifyingness', for which he was becoming famous. Bullied by patrons such as Julius II and Leo X to design works to intimidate their rivals and enemies, his amygdala must have been much more active than that of most artists. Michelangelo was an expert in terror because he expressed it for his patrons and experienced it himself.

If such works are emblematic of Michelangelo's *terribilit*á, the smile of the *Mona Lisa* (**fig. 5)** is emblematic of Leonardo' sweetness. It also reflects the influence of his exceptional imagination, having neural origins, as we learn from his writings and drawings. Already in 1490 Leonardo wrote a note to himself saying: 'Represent all the causes of motion which the skin, flesh and muscles of the face possess, and see if these muscles receive their motion from nerves which come from the brain or not' (Pedretti 1977, I, 345), and we can observe his findings in a sheet in Weimar from around 1506 (**fig. 6**), which reveals the fruit of his anatomical research around that time. As he tells us in the lines at the top

left, the drawing 'shows the nerves that move the eyes in all directions, including the muscles involved, and does the same for the eyelids and brows, as well as for the nose, cheeks and any other part of the human face that moves' (Pedretti 2007, 165). Not only does he show many tiny nerves buried in such expressive parts of the face as the lips and cheeks, but he also shows how these are linked to the brain by larger fibres passing through holes in the skull. The skin is in direct communication with the seat of consciousness. No-one before him had linked the most superficial area of the body to the deepest life of the mind. The benefits for his art were immediate. The drawing reveals Leonardo's preoccupations at the time he was working on the *Mona Lisa* (1503–8). He could never have seen the thousands of tiny fibres with which the flesh beneath her skin was irrigated, but his memory of discovering them under the skin of the faces of cadavers helped him to imagine them, because memories of the past often feed our present imagination. Memory would also have helped him to imagine the nerves in his own face. As he painted *Mona Lisa*'s smile he would have found himself, almost like her lover, smiling back, his response activated by the neural mirroring mechanisms which ensures that from birth babies smile back at their mothers. So effective is Leonardo's communication of warmth that modern viewers, without their being conscious of it, also imagine

themselves having a special relationship with the beautiful Florentine lady, which is why the painting is so famous.

Conclusion

The source of the *Mona Lisa's* power has remained a secret hidden until today. And for one reason. Art historians have not been interested in the nervous system. Leonardo's study of neuroscience enabled him to raise painting to a new level. The study of neuroscience by art historians can do the same for art's history – at least if we are ready to use our imaginations to reconstruct some of the neural correlates of the artistic activities even of the greatest artists. To do so is to finally bridge the depressing gap between the 'brain', familiar to the scientist, and the 'mind' familiar to the humanist.

References:

Bredekamp, H. (2010). *Theorie des Bildakts,* Berlin: Suhrkamp Verlag.

Critchley, H. and S. Garfinkel (2014). Neural correlates of fear: insights from neuroimaging (Review*). Neuroscience and Neuroeconomics*, (3). 111-125.

Dodge, Kenneth A. (1980). Social Cognition and Children's Aggressive Behavior. *Child Development* 51, no. 1 162-70. doi:10.2307/1129603.

Immordino-Yang, M. H., McCall, A., Damasio, H. and Damasio, A. (2009). Neural correlates of Admiration and Compassion, *PNAS* 106, 19, 12, May, 8021.

Eck, C. van (2015). *Art, Agency and Living Presence. From the Animated Image to the Excessive Object*, Boston, De Gruyter (*Studien aus dem Warburg-Haus*, 16),

Freedberg, D. and Gallese, V. (2007). Motion,Emotion and Empathy,

Trends in Cognitive Sciences 11, 197–203

Fried, M. (2001). *Courbet's Realism*, Chicago: Chicago University Press.

Kemp, M. (1989). *Leonardo on Painting*, selected and edited by M. Kemp and M. Walker, New Haven and London: Yale University Press.

Onians, J. (2016), *European Art. A Neuroarthistory*, New Haven and London: Yale University Press.

Mitchell, W.J.T. (2005). *What Do Pictures Want?: The Lives and Loves of Images*. Chicago: Chicago University Press.

Pedretti, C. (1977) *The Literary Works of Leonardo da Vinci*, I. Oxford: Phaidon.

Pedretti, C. (2007) *Il Tempio dell'anima: L'Anatomia di Leonardo da Vinci fra Mondino e Berengario*. Poggio a Cajano: CB Edizioni.

Tanaka, M., Yoshida, M., Emoto, H., and Ishii, H. (2000). Noradrenaline systems in the hypothalamus, amygdala and locus coeruleus are involved in the provocation of anxiety: basic studies, *European Journal of. Pharmacol*ogy, 405: 397–406.

Figures:

1. Bear walking, pigment on rock, c.30,000BC, Chauvet Cave, Vallon Pont d'Arc, Ardeche.

2. Michelangelo Buonarroti, drawings of profiles of bases for New Sacristy, S.Lorenzo, Florence, 1520's, red chalk on paper, Casa Buonarroti, Florence.

3. Michelangelo Buonarroti, egg and dart and frieze of masks, 1520's, New Sacristy, S. Lorenzo, Florence.

4. Michelangelo Buonarroti, drawing of fortifications for Florence, late 1520's, red chalk and ink on paper, Casa Buonarroti, Florence.

5. Leonardo da Vinci, *Mona Lisa*, 1503-19, oil on poplar, Musée du Louvre, Paris.

6. Leonardo da Vinci, *Brain and human nervous system*, 1506-8, ink on parchment, Schloss Museum, Weimar.
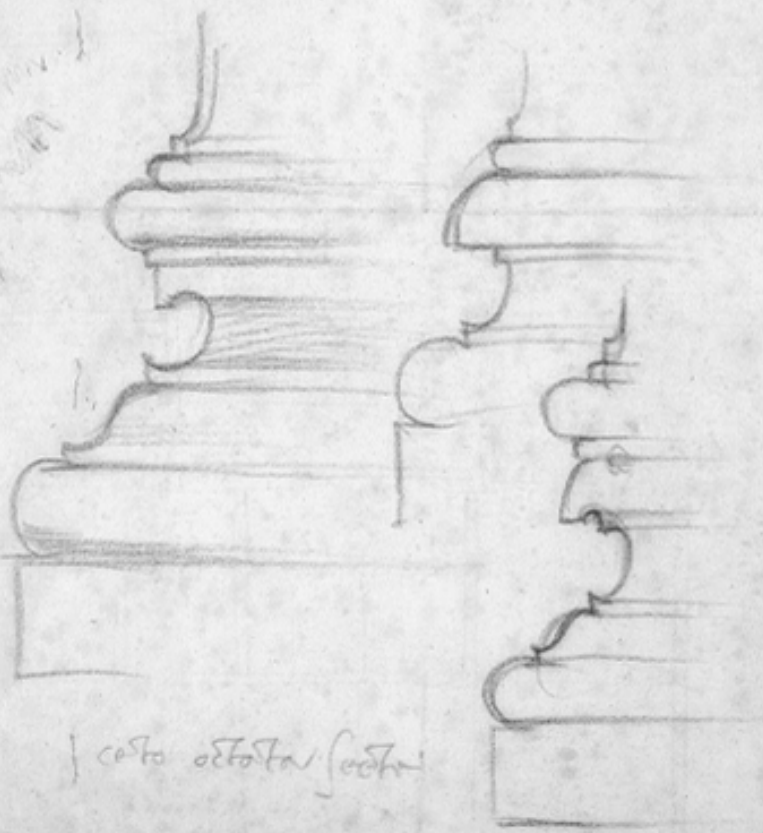
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