Inner Vision

An Exploration of Art and the Brain

Semir Zeki

University College London

OXFORD
UNIVERSITY PRESS

e. It is only with the more
brain that our concept of
now view it as an active
st for knowledge about the
by comparing the selected
ates the visual image in the
o what an artist does. This
ng, namely that there are
the primary visual cortex
participation is essential for
oliferation of newly discov-
pecialised to process differ-
form, colour and motion,
the brain needs to process
partments. And it is this
precipitated by it, that was
g in the view that vision is
ls. But these new facts have
-five years; they were not
urologists speculated about
is therefore not surprising
e in any theory of art or

s' and 'received' by the cortex
by neurologists until very

n, Fisher Unwin, London.
, Gonthier.

visual brain, see S. Zeki
tific, Oxford.
in the Art Theory of the Quatro – and
. According to Gavel, this
onceived of the soul as

nstheorien. Fifth International
Cerebral Cortex, (trans. G. von
eld, 1960.
lindheit, *Arbeiten aus dem*

4

A neurobiological appraisal of Vermeer and Michelangelo

Our new concept of the functions of the visual brain allows us to consider art as being an extension of the functions of the visual brain in its search for essentials. Great art can thus be defined, in neurological terms, as that which comes closest to showing as many facets of the reality, rather than the appearance, as possible and thus satisfying the brain in its search for many essentials. The neurobiological definition of art that I am proposing—that it is a search for constancies, during which the artist discards much and selects the essentials, and that art is therefore an extension of the functions of the visual brain—is meant to have very broad application. Psychologists and neurobiologists commonly speak of constancies for a given attribute of vision, for example colour constancy or form constancy, by which they mean that the colour of an object does not change markedly when viewed in different lighting conditions or that its form does not change when viewed from different distances or angles. But constancy in fact has, or should have, very wide application. It can apply to an object, or to the relations between objects, or to faces or to situations and even to more abstract concepts such as justice, honour and patriotism. Here, I should like to explore two aspects of constancy, linked to each other. The first I will call *situational constancy*—a given situation that has features that are common to many other situations of the same kind, enabling the brain to categorise it immediately as being representative of all. To do so, and to illustrate the broadness of the neurobiological definition, I shall consider the work of Jan Vermeer. The second I will call *implicit constancy*; it is best exemplified by 'unfinished' works where the brain is allowed free play in interpreting the work in as many ways as possible. I will

illustrate that with the unfinished work of Michelangelo. The two types of constancy are in fact linked since in both the inestimable quality is the opportunity that the brain is offered to give several interpretations, all of them valid. I use Vermeer and Michelangelo as examples, and offer a neurological opinion as to why their work is considered to be so deeply satisfying by so many, before turning in later chapters to other and simpler examples. But I hope that the reasoning here is a prototype one which will be found, with variations, to apply to other paintings as well. If I give opinions as to the value of these works it is with diffidence and humility, and then only as a neurobiologist; who am I, after all, to pronounce on these works?

A great deal has been written about Vermeer, 'an artist who remains forever unknown', as Proust astutely called him.[1] His technical virtuosity is unquestioned. His mastery in conveying perspective, in playing with colour, light and shade, and the almost photographic verisimilitude of his work have all been commented on, as has the fact that he used perhaps the most modern technology then known, the *camera obscura*, perhaps aided by the Dutch microscopist Antony van Leeuwenhook who, we are told, was one of his executors.[2] These are not matters that need to be dwelt on. I really want to comment on his narrative art in neurobiological terms.

Paul Claudel,[3] among others, has commented on the banality of Vermeer's subjects—an interior, a maid pouring milk, a girl weighing gold, another reading a letter, a music lesson, all daily events seemingly without special significance. But there is, in Claudel's words, something 'eerie, uncanny' about them.[4] In a good many of his paintings, the viewer is invited to look inside, as if through a keyhole, but not to enter.[5] He is a voyeur, peering into the private moments of private, unknown, individuals; what they are doing, or saying, or thinking is a mystery. Even in those paintings in which the viewer is invited in, so to speak, as for instance in *Gentleman and Girl with Music* or *A Young Woman Standing at a Virginal* (Figure 4.1), a profound mystery is maintained. The subjects that Vermeer treated were not new or original. Many of the same themes are found in the works of other masters of the Dutch school of that period—of Pieter de Hooch, Gerard ter Borch and even Rembrandt. None equalled the psychological power of Vermeer. It is this aspect of Vermeer that, I believe, has the

Figure 4.1
Jan Vermeer, *A Young Woman standing at a Virginal* (© National Gallery, London).

immediate power to attract and provoke, and his technical virtuosity is used in the service of that psychological power, not as an end in itself, unsurpassed though it may be.

Where does this psychological power come from and what, in any case, do we mean by psychological power? I propose to answer this question by looking principally at one of his paintings (Figure 4.2), sometimes called *The Music Lesson* and sometimes *A Lady at the Virginals with a Gentleman*, and now in Her Majesty's collection at Buckingham Palace. It is not the immaculate rendering of the interior, the subtle interplay of light and shade, the brilliant chromatism, the mastery of detail or the exquisite rendering of perspective that most attracts the attention of an ordinary viewer like myself and most others like me. The painting, I believe,

Figure 4.2

Jan Vermeer, *A Lady at the Virginals with a Gentleman* (The Royal Collection © 1999 Her Majesty Queen Elizabeth II). Buckingham Palace, London.

derives its grandeur from the way in which its technical virtuosity is used to generate ambiguity. Here I use the term ambiguity to mean its ability to represent simultaneously, on the same canvas, not one but several truths, each one of which has equal validity with the others.[6] These several truths revolve around the relationship between the man and the woman. There is no denying

which its technical virtuos-
re I use the term ambiguity
taneously, on the same can-
ne of which has equal valid-
ths revolve around the rela-
oman. There is no denying

that there is some relationship between them. But is he her husband, or her lover, or a suitor or a friend? Did he actually enjoy the playing or does he think that she can do better? Is the harpsichord really being used—she is, after all, standing—or is she merely playing a few notes while concentrating on something else, perhaps something he told her, perhaps announcing a separation or a reconciliation, or perhaps something a good deal more banal? All these scenarios have equal validity in this painting which can thus satisfy several 'ideals' simultaneously—through its stored memory of similar past events, the brain can recognise in this painting the ideal representation of many situations—and can categorise the scene represented as happy or sad. This gives ambiguity—which is a characteristic of all great art—a different, and neurological, definition; not the vagueness or uncertainty found in the dictionaries, but on the contrary, certainty—the certainty of many different, and essential, conditions, each of which is equal to the others, all expressed in a single profound painting, profound because it is so faithfully representative of so much.

Schopenhauer once said that painting must strive to 'obtain knowledge of an object, not as particular thing but as Platonic Ideal, that is to say, the enduring form of this whole species of thing'.[7] The Vermeer painting satisfies this condition in that it is the 'enduring form of this whole species of situations'. In any of a number of situations, the scene depicted is what one might actually expect. There is a constancy about it, which makes it independent of the precise situation and applicable to many. The painting is indeed 'a vision of two distant people 'alone together' in a space moved by forces beyond the ken of either',[8] a scenario effectively exploited by Michelangelo Antonioni in some of his films, and most notably in *L'Avventura* and *L'Eclisse*, where once again the viewer becomes imaginatively involved in trying to guess the thoughts of the protagonists. Though it may come as a surprise, there is in this respect, and in terms of the brain, a certain similarity between the paintings of Vermeer and Cubism, especially the later variety which cultivated an ambiguity, in the sense that I have used the term. Writing of Cubism, Gleizes and Metzinger tell us that 'Certain forms should remain implicit, so that the mind of the spectator is the chosen place of their concrete birth'.[9] There could be no more admirable description of the work of Vermeer, where very nearly all is implicit. As with forms and objects in

Cubist art, the brain of the spectator is the chosen place of the birth of many situations in Vermeer's paintings, each one of which has equal validity with the others. The true solution remains 'forever unknown': because there is no true solution, there is no correct answer. It is therefore a painting for many conditions. One viewer, perhaps depending on his mood, may see in it a final moment of doubt about a relationship before husband and wife go out to dinner; another may see in it a moment of satisfaction. Yet others might find a number of solutions, either in one viewing or in many different viewings.

Situational constancy is a subject that neurology has not yet studied, indeed the problem itself has not been addressed. We have hardly begun to understand the simpler kinds of constancy, of form or colour for example, and it is not surprising that neurologists should not have even thought of studying so complex a subject, in which there are so many elements. I would guess that, in broad outline, exposure of an individual to a few situations, a few festive occasions for example, would be sufficient to extract the elements common to all festive occasions. But what brain mechanisms are involved remains a mystery today.

Vermeer was master of all at portraying this ambiguity, which is a feature of many of his paintings. The expression on the face of the apparently pregnant *Woman in Blue* (Figure 4.3, top left) gives little away. What is contained in the letter may be trivial or important; there is no way of telling. There is an implied complicity between the maid and her mistress in *The Letter* (bottom left), just as there is in *Mistress and Maid* (bottom right), but its nature is very difficult to decipher. In the former, the maid could be merely occupying her thoughts with other matters while waiting for her mistress to finish the letter. But she may be watching out to protect her mistress's privacy while composing the letter or, knowing the person being addressed, may be thinking of a phrase to help her mistress in the composition. It is impossible to tell. In the latter, the ambiguous look on the maid's face could communicate a servile assent to what her mistress is saying, or something a little more sinister, perhaps a secret satisfaction at her lady's discomfiture. And what is the *Woman Holding a Balance* (top right) thinking of? It could be something quite banal or something a little more sinister. There is a mystery about it and there are, again, many solutions to that mystery, all of equal

is the chosen place of the
's paintings, each one of
others. The true solution
there is no true solution,
e a painting for many con-
g on his mood, may see in
lationship before husband
see in it a moment of sat-
ber of solutions, either in
ings.

nat neurology has not yet
s not been addressed. We
mpler kinds of constancy,
s not surprising that neu-
of studying so complex a
ments. I would guess that,
dual to a few situations, a
ld be sufficient to extract
ccasions. But what brain
stery today.

ng this ambiguity, which
ne expression on the face
lue (Figure 4.3, top left)
ne letter may be trivial or
here is an implied com-
ress in *The Letter* (bottom
l (bottom right), but its
e former, the maid could
ith other matters while
letter. But she may be
rivacy while composing
addressed, may be think-
n the composition. It is
guous look on the maid's
to what her mistress is
er, perhaps a secret satis-
hat is the *Woman Holding a*
e something quite banal
is a mystery about it and
at mystery, all of equal

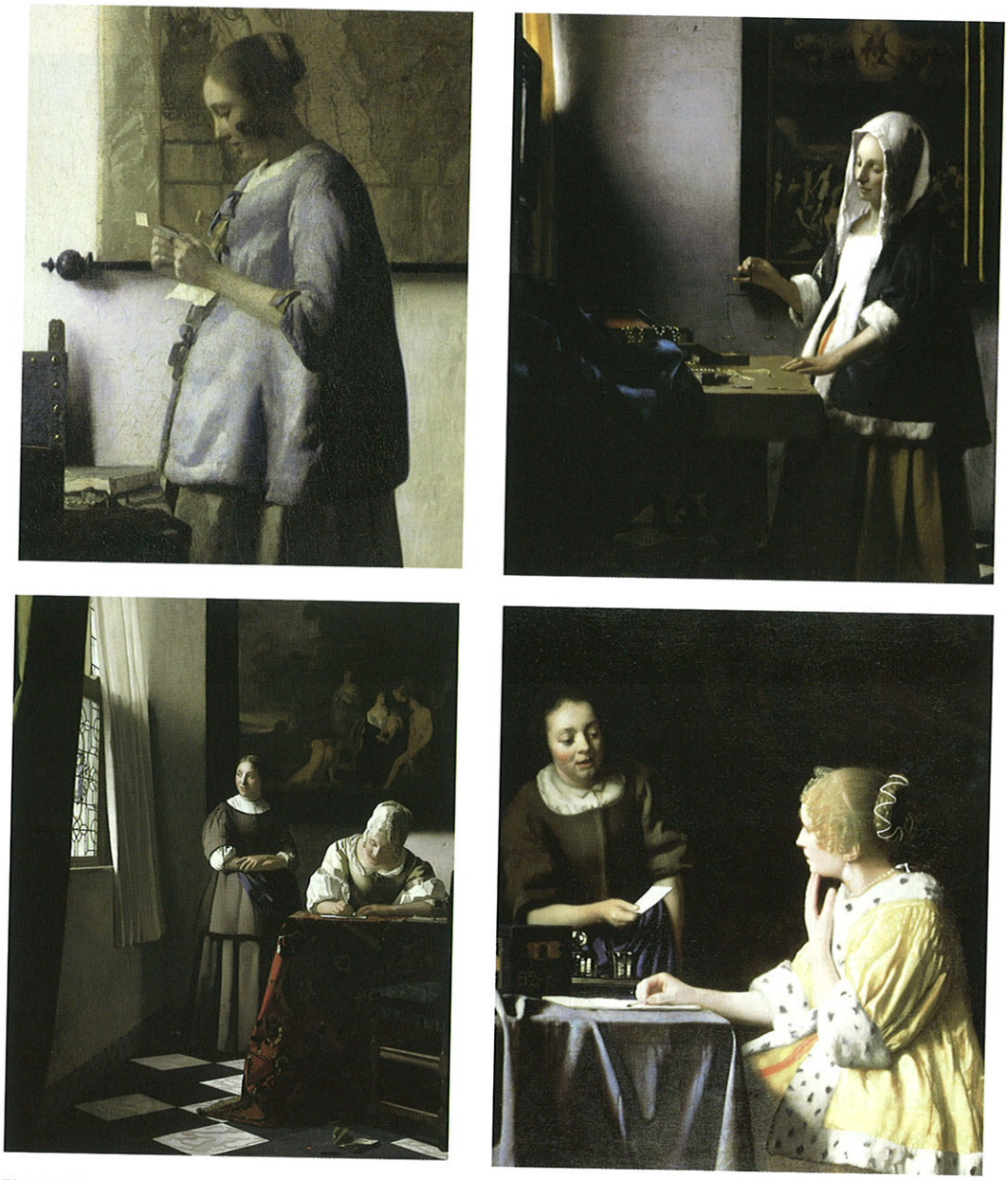


Figure 4.3

Jan Vermeer. Top left: detail from *Woman in Blue*, (© Rijksmuseum, Amsterdam); top right: *Woman Holding a Balance*, (Widener Collection © 1999 Board of Trustees, National Gallery of Art, Washington); bottom left: *The Letter* (© National Gallery of Ireland); and bottom right: *Mistress and Maid* (© The Frick Collection, New York).

validity. The art historian, who will have made a much more detailed study of this painting, may tell us that there is a moral lesson in the work, in that the painting behind the woman is of the Last Judgement. That is for the connoisseur, not for the common man who views the painting for the first time, is mesmerised by its ambiguity, once again used in the neurological,

not the dictionary, sense. And so the list goes on. It is sufficient to look at any of Vermeer's paintings to note that they all have embodied in them that situational constancy, the capacity to be representative of this 'whole species of thing'.

And now we begin to understand, perhaps, what the 'psychological power' of Vermeer's work consists of. It is its capacity to evoke many situations, not one, all with equal validity and hence to cover a 'whole species of situations'. It has the capacity to stir a great deal in the brain's stored memory of past events.

Vermeer's grandeur, neurobiologically speaking, is that he was able to evoke a situational constancy in a single painting. Michelangelo sometimes achieved this same effect in the same way (that is, in a single work) but he also, on occasion, achieved it in a radically different way. All his life, he had been dominated by the overwhelming desire to represent not only physical but also spiritual beauty, as well as divine love. Technically unsurpassed, then or since, of a prodigious imagination and acutely sensitive to beauty, the difficulty he faced was how to represent his Concept of beauty in its many facets in a single work or in a series of individual sculptures. In some areas, the effort was too much, even for the 'divine' Michelangelo. We know that he usually refused to execute portraits, believing that he could not represent all the beauty that his brain had formed a Concept of. Two exceptions are his portraits of Andrea Quaratesi and of Tommaso de' Cavalieri, the young nobleman who had overwhelmed him with his beauty and had come to dominate his emotional life in his later years, unleashing a furious creative energy of great brilliance. As a homosexual, the physical beauty that most affected Michelangelo was that of the male and his brain must have selected and stored a good many more details of the male body than of the female. There is something forever awkward about Michelangelo's females, as a quick glance at the sculptures of the Medici tombs in Florence shows. The breasts are awkwardly placed, in the wrong position, and the bodies a little too muscular, too masculine—not surprising for one who had little interest in, and therefore knowledge of, women; after all, the nearest he came to a woman, physically, was when he kissed the dead hand of the Marchesa di Pescara. With the male body, the result is quite different. Some of these, and especially *The Dying Slave* (Figure 4.4), are in fact homosexual sculptures, again not unexpected from one

t goes on. It is sufficient to
o note that they all have
nstancy, the capacity to be
thing'.
erhaps, what the 'psycho-
ists of. It is its capacity to
h equal validity and hence
. It has the capacity to stir
ory of past events.
ally speaking, is that he
ancy in a single painting.
s same effect in the same
lso, on occasion, achieved
e, he had been dominated
ent not only physical but
e love. Technically unsur-
s imagination and acutely
ced was how to represent
ts in a single work or in a
e areas, the effort was too
elo. We know that he usu-
ing that he could not rep-
formed a Concept of. Two
Quaratesi and of Tommaso
no had overwhelmed him
inate his emotional life in
eative energy of great bril-
beauty that most affected
his brain must have select-
s of the male body than of
forever awkward about
nce at the sculptures of the
ne breasts are awkwardly
bodies a little too muscu-
one who had little interest
en; after all, the nearest he
n he kissed the dead hand
ale body, the result is quite
The Dying Slave (Figure 4.4),
n not unexpected from one

Figure 4.4
Michelangelo, *The Dying Slave* (© Photo RMN, R. G. Ojeda). Louvre, Paris.

whose brain found love and excitement in the male body. It surprises me that in his admirable book,[10] Sir Ernst Gombrich has, like others, been lulled by the title of this work and its history (it was originally intended for the Julius Tomb) to suppose that it represents elements of decay and death. He writes that, in *The Dying Slave*, Michelangelo 'chose the moment when life was just fading, and the body was giving way to the laws of dead matter. There is unspeakable beauty in this last moment of final relaxation and release from the struggle of life—this gesture of lassitude and relaxation.' But *The Dying Slave* has nothing whatever to say about dead matter, at least not visually. It is, instead, a highly sensual, and perhaps even lustful, depiction of the male body, an erotic work. Linda Murray's description of the work as one that 'epitomizes the artist's response to perfect male beauty and is a languid, sensual, relaxed, tender and hauntingly expressive hymn to the major passion of the sculptor's life'[11] is visually much more convincing. It is of course an immense tribute to the ambiguity that Michelangelo could instil in his art that two art historians can interpret the same sculpture in such different ways. It obviously embodies different constancies.

The depiction of physical beauty must have been relatively simple compared to the difficulties of depicting spiritual beauty. As a Neo-Platonist, Michelangelo would probably have found it difficult, and even abhorrent, to separate physical from spiritual beauty and there is in fact a powerful spiritual element in the setting for some of his sculptures of male bodies, for example in the St Peter *Pietà*. But more difficult still must have been the depiction of divine love. A devout Catholic, Michelangelo found that divine love in the life of Jesus, and particularly in the last moments on the Cross and after the Descent from it, which is the subject of several of his sculptures. This was a Herculean task and one solution that Michelangelo seems to have adopted was to leave many of his sculptures unfinished. Among the most famous are the Rondanini *Pietà* which he was still working on when he died (Figure 4.5a), thus making it plausible to suppose that it was not intentionally left unfinished, even though he had started work on it long before his death. But the same cannot be said of his other unfinished sculptures, paintings and drawings, given that he left three-fifths of his marble sculptures incomplete. His *San Matteo* (Figure 4.5b) was ostensibly left unfinished because he was called

Figure 4.5

Michelangelo (a) The Rondanini *Pietà* (© Museo d'Arte Anticadel Castello Sforzesco, Milan.) and (b) *San Matteo* (Reproduced by permission of the Ministero per i Beni Culturali e Ambientali, Rome.) Accademia delle Belle Arti, Florence.

to Rome, though he had ample opportunity to finish it later. The *Bearded Slave* is another example as is *Day* for the tomb of Giuliano de' Medici (Figure 4.6). There are also unfinished drawings and paintings, for example the *Crucifixion with the Virgin and St. John* of 1550, the *Crucifixion* of 1540 (Figure 4.7) and the *Manchester Madonna* (Figure 4.8), where the two figures to the left are almost given in outline alone, thus making a stark comparison with the rest of the painting. The reason why Michelangelo who, according to his young disciple Condivi, disapproved of the unfinished state of Donatello's sculptures, left these works unfinished has been discussed and debated since the time of Giorgio Vasari who believed, like Condivi, that 'Michelangelo's *non finito* reflects the sublimity of his ideas, which again and again lay beyond the reach of his hand.'[12] My interpretation is that it was deliberate, especially since they do not all appear to have been intentionally abandoned, which is indeed one reason why their unfinished state has been discussed in such detail. It is in a sense a neurological trick, endowing the brain with greater imaginative powers. It is this

nity to finish it later. The
or the tomb of Giuliano
nfinished drawings and
h *the Virgin and St. John* of
4.7) and the *Manchester*
res to the left are almost
rk comparison with the
helangelo who, accord-
roved of the unfinished
works unfinished has
e of Giorgio Vasari who
o's *non finito* reflects the
in lay beyond the reach
t was deliberate, espe-
een intentionally aban-
eir unfinished state has
se a neurological trick,
ative powers. It is this

Figure 4.6

Michelangelo, *Day* (Bridgeman Art Library London/New York.) Tomb of Giuliano de' Medici, Medici Chapel, Florence.

imaginative involvement that allows an art critic to write that even in the unfinished Rondanini *Pietà*, 'Michelangelo subordinates the representation of physical beauty to the feeling of emotional life [through the use of] flat surfaces, straight lines and the inertia of an amorphous mass lacking contrasts of light and shade' and that the emotional content of the work 'comes to represent in the personal life of the artist the fulfilment of his longings, that state of beatitude toward which his unsatisfied soul aspired.'[13] I doubt very much that so distinguished a critic as Charles De Tolnay would have been able to write in these terms of a work that had been left hastily unfinished. By thus leaving them *non finito*, Michelangelo invites the spectator to be imaginatively involved, and the spectator's view can fit many of the Concepts, the stored representations, in his brain; there is, in short, an ambiguity and therefore a constancy about these unfinished works. But the constancy is achieved in a radically different way from that achieved in finished works like, say, the St Peter *Pietà* or *The Dying Slave*. Here the forms remain almost totally implicit and are born in the spectator's brain. Perhaps the best hint at what Michelangelo intended is derived from his *Rime* or *Sonnets*, where, next to his works, he best expounds his views on art and beauty. In one, dedicated to Vittoria Colonna, the Marchesa di Pescara, he wrote:

The greatest artists have no thought to show that
Which the marble in its superfluous shell does not contain
To break the marble spell is all that the hand
That serves the brain can do[14]

The evocative power of Michelangelo's works is prodigious, but the powers that these works evoke, and from which they are derived, are so varied that they cannot be represented in a single work or a series of single works, even with the greatest of struggles. That struggle can be a life-giving force, as with Beethoven who wrote in his Heilingenstadt Testament, 'It would have taken little for me to put an end to my life; it was only art which held me back.' Or it can lead to the realisation of the impossibility and even futility of the task. I think that the mighty Michelangelo, that 'masterful and stern, life-wearied and labour hardened'[15] genius of Western art, well understood this and came to have doubts about the capacities of art in his last years. Historians of art will no doubt have many reasons for why the greatest artist that the

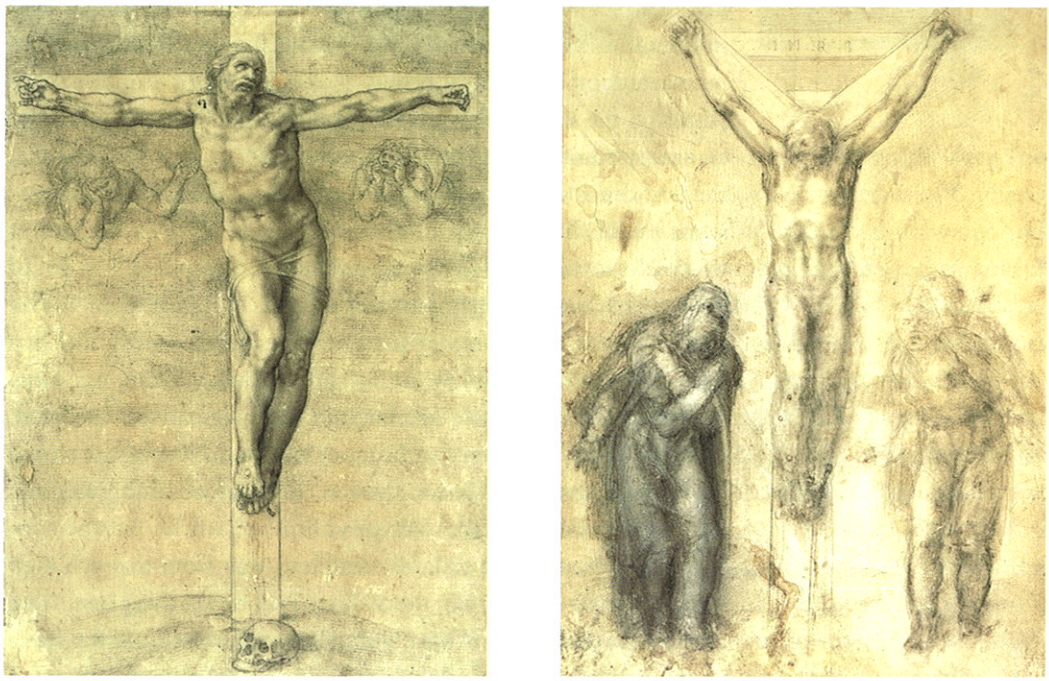


Figure 4.7
Michelangelo, *Crucifixion* and *Crucifixion with the Virgin and St John* (© British Museum, London).

how that
ll does not contain
nand

elo's works is prodigious,
and from which they are
be represented in a single
with the greatest of strug-
force, as with Beethoven
nent, 'It would have taken
t was only art which held
n of the impossibility and
mighty Michelangelo, that
labour hardened'[15] genius
and came to have doubts
ears. Historians of art will
the greatest artist that the

Figure 4.8
Michelangelo, *The Virgin Child with Saint John and Angels (The Manchester Madonna)* (© National Gallery, London).

West has produced should have thus turned against art. There is no doubt that he thought that his earlier art, in exaltation of the body, may have been sinful. But my interpretation of the following lines from a sonnet dedicated to Vasari is that, like Plato, he saw the limitation and even futility of the work of art when compared to the almost infinite range of the brain's stored record, or of the imagination as he might have said:

> I now know how fraught with error was that vivid imagination
> That made art my idol and my king
>
> No brush, no chisel, can quieten the soul
> Once it turns to contemplate the divine love of Him who
> From the Cross outstretched His arms to
> Take us unto Himself.[16]

So wide was the brain's imagination of the last moments on the Cross that a single finished work could not capture it all. Leave it,

therefore, to the brain of the spectator to give birth to more forms. 'Something', Schopenhauer has said, 'and indeed the ultimate thing, must always be left over for the imagination to do'.[17] Plotinus, the Greek Neo-Platonist from Alexandria, with whose writings Michelangelo was no doubt well acquainted, had, after all, uttered a profound neurological truth about the forms that Michelangelo thought required nothing more than a hand that obeys the brain to uncover. The 'form', Plotinus had said, 'is not in the [stone]; it is in the designer before it ever enters the stone'.[18] And it is because it is also in the spectator's brain that the spectator can become imaginatively involved in creating several more forms out of the unfinished work of Michelangelo. This pre-existent form is one that we shall encounter again in writings on Cubism, which itself provides an excellent example of how artists can mimic the functions of the visual brain, or at least try to do so.

---

1. Proust, M. (1952). Pages sur Vermeer, in *Vermeer de Delft*, La Pléiade, Paris.
2. Nash, J. (1991). *Vermeer*, Scala Publications, London.
3. Claudel, P. (1946). *L'oeil écoute*, Gallimard, Paris.
4. Claudel used the English terms, there being no good French equivalent.
5. Here I disagree with Claudel who says that the spectator is immediately invited in. This is true of some, but not most, of Vermeer's work; a notable exception is *Woman with a Pearl Earring* (see Fig 17.10).
6. Zeki, S. (1990). In conversation with Balthus, *Connaisance des Arts*, 1990, Paris.
7. Schopenhauer, A. (1844). *The World As Will and Idea*, Third Book, from *Philosophies of Art and Beauty* (ed. A. Hofstader and R. Kuhns), University of Chicago Press, Chicago, 1964.
8. Snow, E. (1994). *A Study of Vermeer*, University of California Press, Berkeley.
9. Gleizes, A. and Metzinger, J. (1913). *Cubism*, Fisher Unwin, London.
10. Gombrich, E. H. (1984). *The Story of Art*, Phaidon, Oxford.
11. Murray, L. (1980). *Michelangelo*, Thames and Hudson, London.
12. Schulz, J. (1975). Michelangelo's unfinished works, *Art Bulletin*, **58**, 366–73.
13. Tolnay, C. (1934). Michelangelo's Rondanini *Pietà*, *Burlington Magazine*, **65**, 146–57.
14. I have used the translation by J. A. Symonds (1904), *The Sonnets of Michael Angelo Buonarroti*, Smith, Elder & Co., London; other translations do not use the word brain. The original uses the word *intelletto*, not brain. In Latin, Clements tells us, *intellectus* meant perception or 'a perceiving' (see p. 15 of *Michelangelo's Theory of Art*, by R. J. Clements (1961), New York

o give birth to more forms.
'and indeed the ultimate
the imagination to do'.[17]
n Alexandria, with whose
well acquainted, had, after
ruth about the forms that
g more than a hand that
Plotinus had said, 'is not in
it ever enters the stone'.[18]
tor's brain that the specta-
l in creating several more
f Michelangelo. This pre-
unter again in writings on
ent example of how artists
ain, or at least try to do so.

---

rmeer de Delft, La Pléiade, Paris.
London.
Paris.
ng no good French equivalent.
t the spectator is immediately
ost, of Vermeer's work; a
ng (see Fig 17.10).
aus, *Connaisance des Arts*, 1990,

nd Idea*, Third Book, from
and R. Kuhns), University of

ty of California Press,

, Fisher Unwin, London.
aidon, Oxford.
Hudson, London.
ed works, *Art Bulletin*, **58**,

ni Pietà, *Burlington Magazine*, **65**,

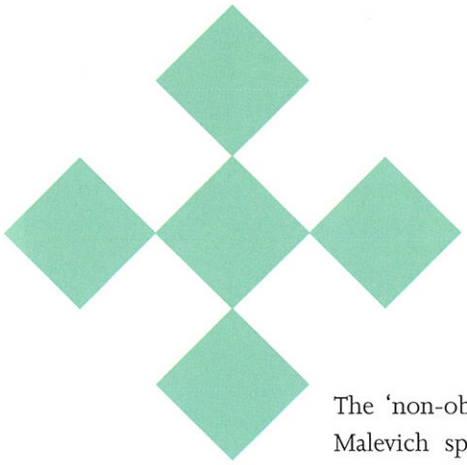
ds (1904), *The Sonnets of Michael*
n; other translations do not
word *intelletto*, not brain. In
rception or 'a perceiving'
J. Clements (1961), New York

University Press, New York); Dante wrote in the *Convivio*: 'I say intellect for the noble part of our soul which, in a common word, can be called mind'; see Gilbert, C. (1962). Review of R. J. Clements' *Michelangelo's Theory of Art*, *Art Bulletin*, **44**, 347–55. Either way, Symonds has, astutely in my view, rendered it into brain.

15. Article on Michelangelo in *The Encyclopaedia Britannica*, 1967.
16. Blunt, A. (1962). *Artistic Theory in Italy 1450–1600*. Oxford University Press, Oxford.
17. Schopenhauer, A. (1844). *The World as Will and Idea*, Chapter 34, Supplement to the Third Book, Loc. cit.
18. Plotinus, *Ennead V*, Eighth Tractate, reprinted in *Philosophies of Art and Beauty* (ed. A. Hofstadter and R. Kuhns), University of Chicago Press, Chicago, 1964.

in the different areas of the
speak of the *art of the receptive*
ilored to the physiology of
receptive field. I do not
ern art can be so analysed,
for the aesthetic quality of
responses of single cells.
gle cell physiology and the
that I describe below is far
y problems which I shall
etween the physiology of
f modern art is compelling

12



Mondrian, Malevich and the neurophysiology of oriented lines

The 'non-objective art' and the 'non-objective sensation' which Malevich speaks of is the art of a brain that is already well acquainted with the visual world, a brain that has already selected the essentials of objects and surfaces, that through the activity of its specialised cells and areas can recognise elements of the visual scene readily and reproduce them from memory. And we find that as art developed in the more modern era but remained true to its mission of representing essentials and constants, so it became more and better tailored to the physiology of the visual areas and in particular to the responses of single cells in them, since the function of these areas is, similarly, to distil the essential features of the visual world. There is here an *Einfühlung*, that untranslatable term that signifies a link between the 'pre-existent' forms within the individual and the forms in the outside world which are reflected back, 'the art of painting new ensembles borrowed not from the visual reality but from that which is suggested to the artist by instinct and intuition' as Guillaume Apollinaire[1] said of Cubism.[2] We shall find, at any rate, that there is a compelling relationship between much that modern art has produced and the single cell physiology of the visual brain. In this chapter, I want to explore the relationship between modern works that have emphasised lines and the reaction of cells in the brain that are selective for lines of specific orientation.

The Cubist approach to form constancy is not the only one. Other artists, with the same broad aim, have used a different approach and asked whether there are any universally present components of form, those that constitute the essential part of all

a

b

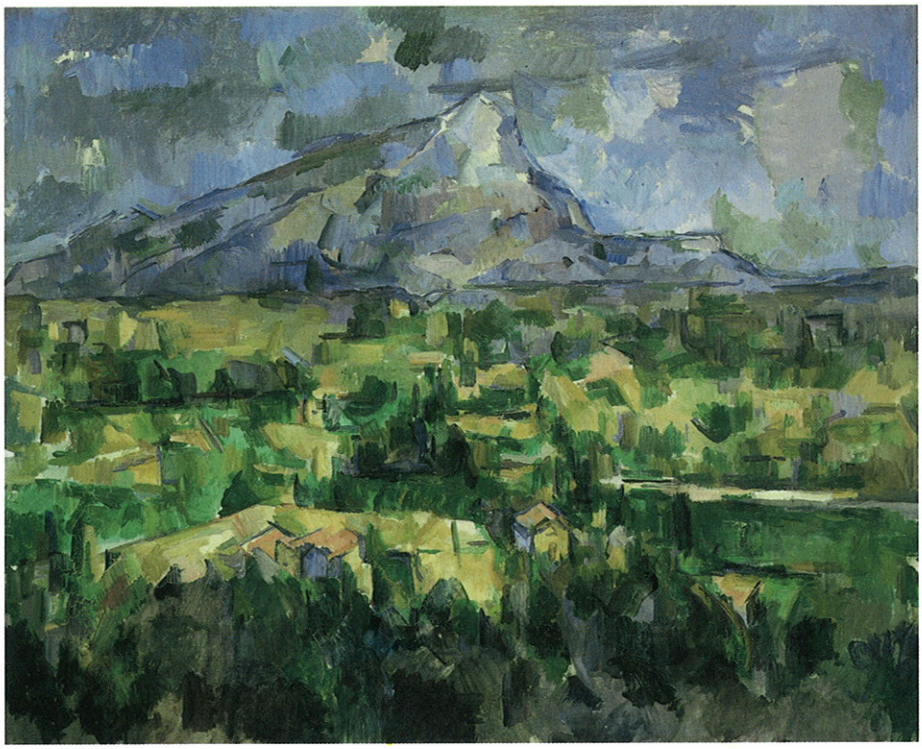
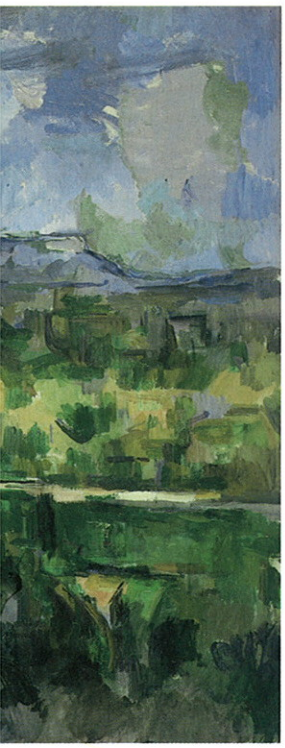


Figure 12.1

(a) Paul Cézanne, *Baigneurs* (© Photo RMN, Hervé Lewandowski) Musée d'Orsay, Paris. (b) Paul Cézanne, *Montagne Sainte Victoire* (© Philadelphia Museum of Art, The George W. Elkins Collection).



Orsay, Paris. (b) Paul Cézanne, Collection).

forms. It is this search that led to the emergence of lines as a dominant form in many modern works of art. One of the greatest to undertake this enquiry was Cézanne who tried to reduce the huge variety of forms in nature to a few elements. As is well known, this led him to the cone, the sphere and the cube—each one of which possesses solidity. To me, as a neurophysiologist, there is another aspect that is far less emphasised, if indeed it is emphasised at all, but which has equal status with the above three: this is the line and the edge. In this regard, Cézanne's painting entitled *Bathers [Baigneurs]* with its heavy emphasis on lines (Figure 12.1a) and his succesive paintings of the Montagne Sainte Victoire are of special interest (Figure 12.1b). There are different interpretations of why Cézanne painted the Montagne Sainte Victoire, near Aix, so often. One critic, for example, has seen the obsession with the mountain as an attempt to dominate[3] his society, that of Aix. Such interpretations, regardless of their validity, are not interesting to our enquiry or at least far less interesting than the visual evolution of his art, starting with naturalistic representations and ending with a series of lines grouped into squares, an approach he used in other late paintings, of which *La Route Tournante* and *Rochers prés des grottes au dessus de Château Noir* (Figure 12.2a) are good examples. If, in Roger Fry's words, 'it is characteristic of Cézanne's method of *interpreting form*, thus to seize on a few clearly related, almost geometrical elements, and then ... to give every part of the contour the utmost subtlety of variation which his visual sensibility could discover' (my emphasis and ellipsis),[4] it must be said that the line, the square and the edge constitute the 'few clearly related geometrical elements' that Cézanne seized upon. The emphasis on lines is just as striking as that on the square, as a casual glance at, for example, *Le Lac d'Annecy* (Figure 12.2b) will show. It is interesting to note that another artist who, like Cézanne, found neither fame nor fortune in his society because his art was regarded as 'decadent', is the Russian Mikhail Vrubel. Vrubel was especially admired by Gabo, who considered him to have 'revived the concept in visual art that the *fundamental visual elements* are of decisive importance in the creation of a pictorial or plastic image' (my emphasis).[5] Gabo emphasised the similarity between Vrubel's art and that of Cézanne and, to illustrate his point, chose, among other examples, a detail from Vrubel's *Madonna and Child* (c.1890) (Figure 12.3a) and compared

a

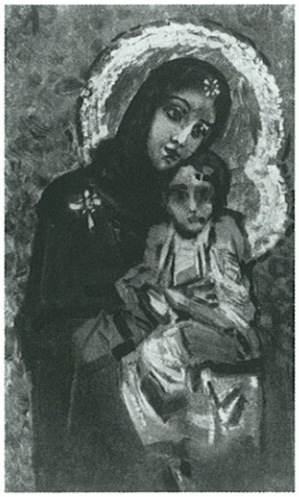
b

Figure 12.2

(a) Paul Cézanne, *Rochers prés des grottes au-dessus de Château—Noir* (© Photo RMN, Hervé Lewandowski). Musée d'Orsay, Paris. (b) Paul Cézanne, *Le Lac d'Annecy* (© The Courtauld Gallery, London).

Figure 12.3
(a) Mikhail Vrubel, *Madonna and Child*; to the right, a detail.
(b) Paul Cézanne (1905) detail from Figure 12.1, *Montagne Sainte Victoire* (© Philadelphia Museum of Art, The George W. Elkins Collection).

a



b

it with a detail from Cézanne's 1905 version of the *Montagne Sainte Victoire* (Figure 12.3b). The emphasis on lines, edges, and rectangles in both is striking.

This emphasis upon the line is not of course unique to Cézanne or indeed to modern art. It forms the basis of many drawings from the Italian Renaissance onwards. It is a characteristic of many paintings as well, most notably those of Uccello where the prominent lines defining the spears in his battle scenes are almost a trademark. But, after Cézanne, two modern masters emphasised it especially and their legacy has had a deep influence on much of modern painting.

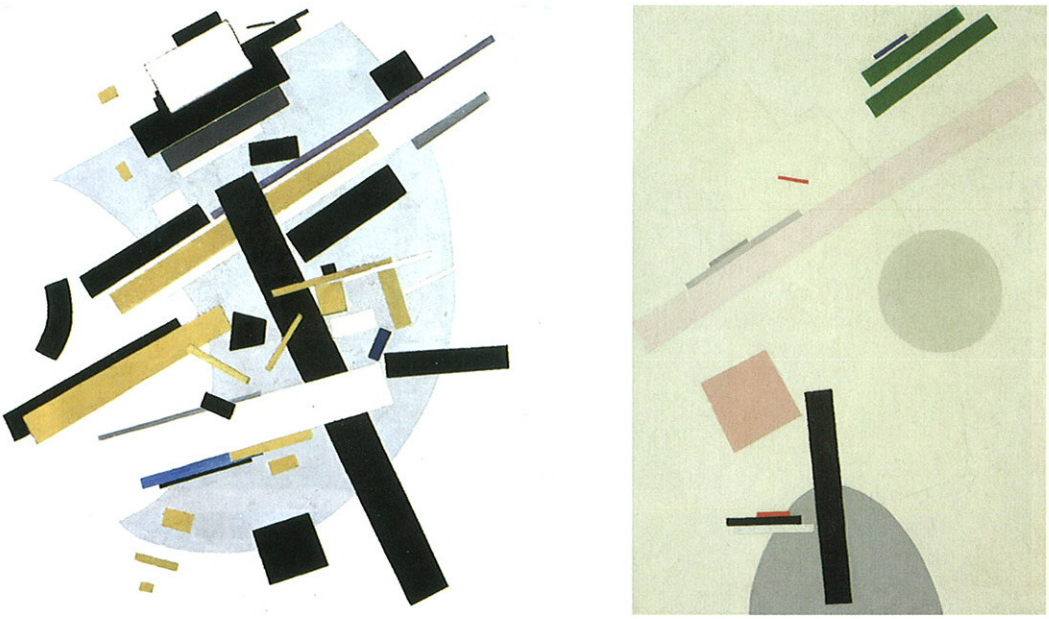
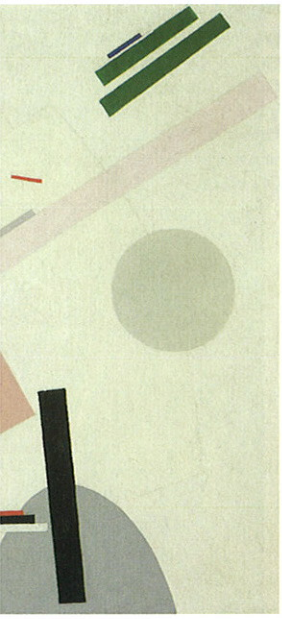


Figure 12.4

Kazimir Malevich.
Left: *Suprematism: Supermus N58* (© The State Russian Museum, St. Petersburg). Right: *Suprematist Painting.* (1916–17) Oil on canvas, $38^1/_2 \times 26^1/_8$" (97.8 × 66.4cm). The Museum of Modern Art, New York. Photograph © 1999 The Museum of Modern Art, New York.

Malevich proclaimed the importance of non-objective sensation and of non-objective art, the art 'that wants nothing further to do with the object, as such'. In his paintings, he emphasised the line, the square and rectangle, the cross and the circle. In fact many of his rectangles are almost lines or bars and have straight edges, as do the crosses. The rectangles of Malevich and his Russian Constructivist successors (Figure 12.4) become lines when viewed from a distance. The line that is so prominent a part of Malevich's work, and which Kandinsky also emphasised, is in fact a prominent feature of many even more modern paintings, amongst which one can enumerate the work of Barnett Newman, Ellsworth Kelly, Robert Ryman, Robert Motherwell, Gene Davis, Robert Mangold, Ad Reinhardt and Franz Kline, among many others (Figure 12.5).

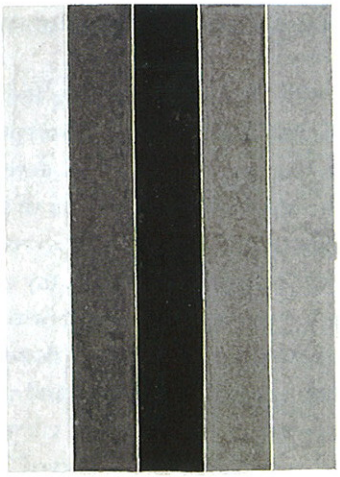
Piet Mondrian ended by emphasising the line too, but reached that end from a different beginning and with a different approach. 'Art', he wrote, 'has two main human inclinations ... One aims at the *direct creation of universal beauty,* the other at the *aesthetic expression of oneself*' (original emphasis, my ellipsis).[6] The first is more or less objective, the latter subjective. The first had to be objective because 'Since art is in essence universal, its expression cannot rest on a subjective view' even if 'our human capacities do



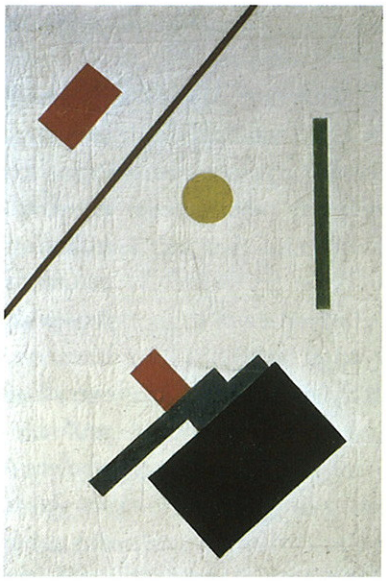
e of non-objective sensa-
hat wants nothing further
paintings, he emphasised
ross and the circle. In fact
or bars and have straight
les of Malevich and his
ure 12.4) become lines
hat is so prominent a part
sky also emphasised, is in
more modern paintings,
work of Barnett Newman,
Motherwell, Gene Davis,
anz Kline, among many

the line too, but reached
g and with a different
n human inclinations ...
eauty, the other at the *aes-*
s, my ellipsis).[6] The first is
ctive. The first had to be
e universal, its expression
'our human capacities do

a



b



c

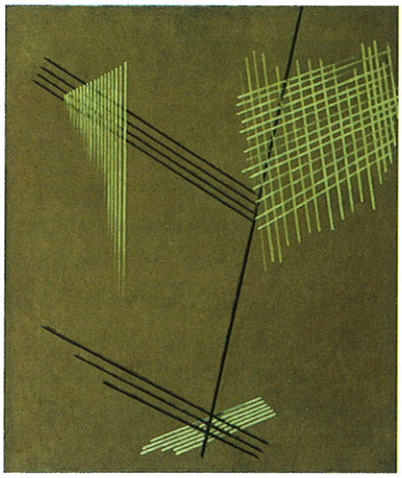


Figure 12.5

(a) Ellsworth Kelly, *IX* from the series *Colored Paper Images*. (1976). Paperwork, molded and dyed in color, composition: (irregular $46^{1}/_{16} \times 32^{1}/_{16}$″ (117 × 81.5 cm). The Museum of Modern Art, New York. Gift of the artist. Photograph © 1999 The Museum of Modern Art, New York. (b) Kazimir Malevich, *Suprematist Composition*, 1915 (Museum of Art, Tula/Bridgeman Art Library, London/New York). (c) Alexander Rodchenko *Non-Objective Painting*. 1919. Oil on canvas, $33^{1}/_{4} \times 28$″ (84.5 × 71.1cm). The Museum of Modern Art, New York. Gift of the artist, through Jay Leyda. Photograph © 1999 The Museum of Modern Art, New York.

not allow of a perfectly objective view.' Art, he believed, 'shows us that there are also constant truths concerning forms' and it was the aim of objective art, as he saw it, to reduce all complex forms in this world to one or a few universal forms, the constant elements which would be the constituent of all forms, to 'discover *consciously or unconsciously* the fundamental laws hidden in reality'

(my emphasis). He had started with naturalistic painting and had been much attracted to Cubism. But 'Cubism did not accept the logical consequences of its own discoveries; it was not developing abstraction towards its ultimate goal, the expression of pure reality ... To create pure reality plastically it is necessary to reduce natural forms to the *constant elements*' (original emphasis, my ellipsis)[7] which, in the case of form, led to the vertical and horizontal lines, or so he believed. These 'exist everywhere and dominate everything'. Moreover, the straight line, 'is a stronger and more profound expression than the curve'[8] because 'all curvature resolves into the straight, no place remains for the curved'.[9] He sought, in other words, the Platonic Ideal for form (though he did not describe it in these terms). He wrote, 'Among the different forms, we may consider those as being neutral which have neither the complexity nor the particularities possessed by natural forms or abstract forms in general'.[10]

This emphasis on lines in many of the more modern and abstract works of art does not, in all probability, derive from a profound knowledge of geometry but simply from the experimentation of artists to reduce the complex of forms into their essentials or, to put it in neurological terms, to try and find out what the essence of form as represented in the brain may be. I emphasise yet once again that this is my interpretation, not that of artists. Mine is not of course the only valid interpretation, but it is one interpretation. And I cannot see that it is any less valid than other interpretations. Kahnweiler tells us that 'it is only the appearance of straight lines in cubist work ... that instilled a belief in geometry of which, in reality, there is no trace. These straight lines, reflections of the basis, of the a priori, of all human visual perception, will be found, in effect, in all plastic works of art, once the preoccupation with imitation has disappeared' (my ellipsis).[11] This is as explicit a statement as any, coming from one who, if not an artist himself, was at least well acquainted with artists and their work, that the artist is trying to represent the essentials of form as constituted in his visual perception, which I take to mean the brain. Gleizes and Metzinger, both artists, emphasised the straight lines and the relationship that they have to each other, as did Mondrian. They wrote, 'The diversity of the relations of line to line must be indefinite; on this condition it incorporates quality, the incommensurable sum of the *affinities*

turalistic painting and had
Cubism did not accept the
veries; it was not develop-
al, the expression of pure
ly it is necessary to reduce
iginal emphasis, my ellip-
the vertical and horizontal
everywhere and dominate
e, 'is a stronger and more
'[8] because 'all curvature
nains for the curved'.[9] He
deal for form (though he
wrote, 'Among the differ-
being neutral which have
arities possessed by natural

of the more modern and
probability, derive from a
simply from the experi-
mplex of forms into their
terms, to try and find out
ed in the brain may be. I
ny interpretation, not that
ly valid interpretation, but
see that it is any less valid
tells us that 'it is only the
work ... that instilled a
y, there is no trace. These
the a priori, of all human
fect, in all plastic works of
tion has disappeared' (my
t as any, coming from one
east well acquainted with
is trying to represent the
visual perception, which I
Metzinger, both artists,
relationship that they have
vrote, 'The diversity of the
inite; on this condition it
rable sum of the *affinities*

perceived between that which we discern and that which pre-exists within us' (my emphasis).[12] Once again, I interpret 'that which pre-exists within us' to mean that which is in our brains. Although Gleizes and Metzinger are here more properly talking about the relations between lines, it is nevertheless lines that they have chosen to emphasise.

Equally interesting are the speculations of Mécislas Golberg in *La Morale des lignes*. Golberg was a colourful and tragic figure who, it has been said, may have had a powerful influence on Matisse. It has even been maintained that Matisse's *Notes d'un peintre* was co-authored by Golberg. Emphasising lines, and especially the vertical and the horizontal, Golberg wrote of returning to geometry, 'but a geometry that is implied, submissive to the laws of simplification and unification' which he thought was important for 'representing reality in its most abstract form' which in turn was essential for 'the simplification and the modernisation of drawing'.[13] And although he attached subjective sentiments to the vertical and the horizontal, it is nevertheless these that he thought of as important in modernising art. 'And is this not already a very appreciable contribution to artistic evolution and, above all, to the intelligence of contemporary art where the line, presented sometimes without the support of a traditional 'subject', has to be interpreted and understood by itself and for itself?'[14]

The above examples are sufficient to convince that, during the process of simplification in art, the line has had a special place and a dominant role. I have wondered whether there is any relationship between this emphasis on lines that artists, with the common aim of representing the 'constant truths concerning forms', have used and the neurophysiology of the visual cortex, where cells that are selectively responsive to lines of specific orientation predominate (orientation selective cells). Again, this is my interpretation, not that of artists, most of whom had finished their work or were dead long before orientation selectivity in the visual brain was discovered by David Hubel and Torsten Wiesel in 1959.[15] Indeed the intellectual reasoning that artists give us as to why and how they came to emphasise lines shows that they reached this common conclusion about forms through what they suppose are different intellectual routes. As a neurobiologist, I find the intellectual description of artists far less interesting and convincing than their visual creations—indeed I find much of these

intellectual wanderings somewhat distracting and, like Proust, 'Chaque jour j'attache moins de prix à l'intelligence'! ['Every day, I attach less importance to intelligence'].[16] Their visual creations, on the other hand, bear a far more compelling relationship to the neurophysiology of the organ that is the most critical for producing visual art, namely the visual brain.

The discovery that a large group of cells respond selectively to lines of specific orientation was a milestone in the study of the visual brain. Even today, after having seen thousands of orientation selective cells in the cortex over a very long period of time, I cannot cease to be fascinated when I watch a single cell, among billions of cells in the cortex, respond with such precision, regularity and predictability to a line of a given orientation, and also watch its responsiveness diminish progressively as one changes the orientation from the optimal one until, at the orthogonal orientation, there is no response at all (see Figure 11.2). Physiologists consider that orientation selective cells are the physiological building blocks for the neural elaboration of forms, though none of us knows how complex forms are neurologically constructed from cells that respond to what we regard to be the components of all forms. In a sense, our quest and our conclusion is not unlike those of Mondrian, Malevich and others. Mondrian thought that the universal form, the constituent of all other more complex forms, is the straight line; physiologists think that cells that respond specifically to what some artists at least consider to be the universal form are the very ones that constitute the building blocks which allow the nervous system to represent more complex forms. I find it difficult to believe that the relationship between the physiology of the visual cortex and the creations of artists is entirely fortuitous. The above fortifies this prejudice of mine.

A great number of cells in area V1 are orientation selective but such cells constitute the majority group in other visual areas as well, and most especially in an area that surrounds V1, known as V2, and in the areas constituting the V3 complex. In areas with heavy concentrations of orientation selective cells, the latter are not randomly distributed with respect to their preferred orientations. On the contrary, there is a great deal of order in the cortical position of such cells with respect to one another, as there seems to be with almost everything else in the cortex. This meticulous order becomes readily apparent when one charts the

orientation preference of successive cells in the cortex. If one looks in a direction that is perpendicular to the cortical surface, one finds that the successive cells, ones that are stacked upon each other in a sort of column that extends from cortical surface to white matter, all respond to a line of the same orientation (Figure 12.6). If instead one looks in a direction that is at an angle of 45° to the cortical surface, one finds that the preferred orientation of the lines that cells are selective to changes gradually (Figure 12.6). Orientation selective cells, in other words, are not haphazardly and randomly distributed in the cortex, but are strongly organised according to common preferences.

Perhaps we cannot relate the totality of the art of Mondrian to the responses of the orientation selective cells in the visual cortex. But what we can say with certainty is that, when we view one of Mondrian's abstract paintings in which the emphasis is on lines, or when we view some of the paintings of Malevich, or Rozanova or Barnett Newman, large numbers of cells in charted visual areas of our brains will be activated and will be responding vigorously,

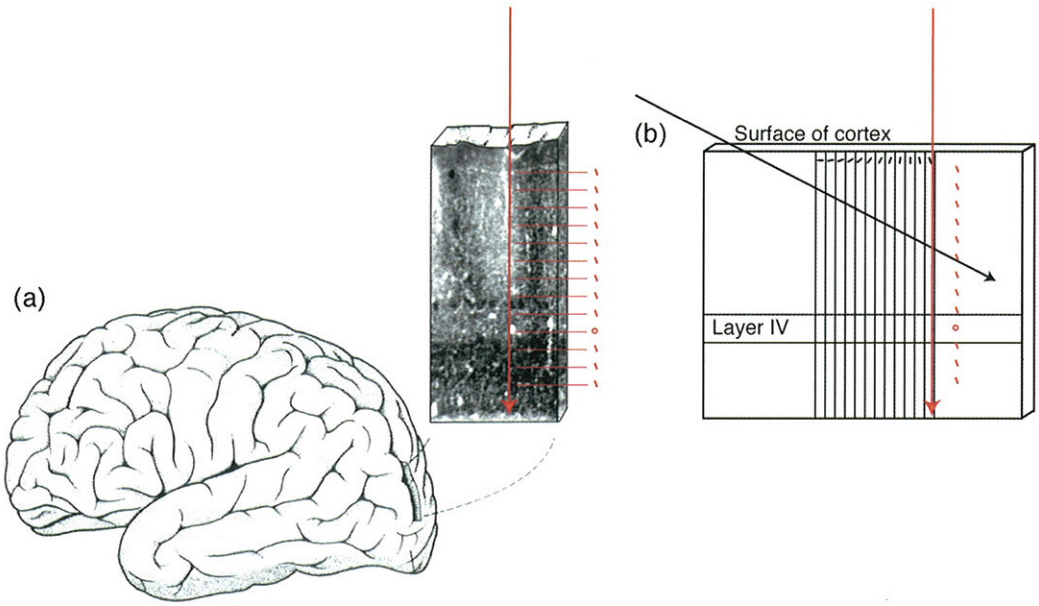


Figure 12.6

Cells that prefer a particular orientation are grouped together in columns extending from the surface of the cortex to the white matter (centre). Cells in neighbouring columns have different orientational preferences, but (b) there is an orderly change in orientational preference as one moves from one column to another. (Modified from D. H. Hubel and T. N. Wiesel (1977), *Proc. R. Soc. Lond. B*, **198**, 1–59.).

provided a line of a given orientation falls on the part of the visual field that a cell with a preference for that orientation 'looks at'. Whether the responses of these orientation selective cells provide the aesthetic experience is a question that neurology is not ready to answer. What is certain is that if such cells are lost by not being adequately visually nourished during the critical period or as a consequence of lesions in the brain produced by vascular or other damage, no experience, aesthetic or otherwise, of the work of Mondrian and others in which lines are emphasised, is possible.

Because orientation selective cells have a very wide distribution in the cortex, and are found in many areas, there are no reported cases in which, following selective lesions, patients are selectively unable to see oriented lines. But there is a severe condition in which patients, following carbon monoxide poisoning[17] or a heart attack that is severe enough to deprive the brain of oxygenated blood even for a relatively brief period,[18] become virtually blind and yet are able to see colours (see also chapter on fauvism). Such patients, even though they can see the colour component of the creations of Mondrian and Malevich, have no appreciation for the lines, the forms, which quite simply do not exist for them. The aesthetic quality of the work of Mondrian, and much else besides, is lost on them.

Mondrian himself was quite fussy about the orientation of the lines in his work. His abhorrence of the curved line was as nothing compared to his hatred of the diagonal. Highly irritated by the fact that Theo van Doesburg, the founder of the De Stijl group, used diagonals, Mondrian wrote to him that, 'Following the high-handed manner in which you have used the diagonal, all further collaboration between us has become impossible. For the rest, *sans rancune*.'[19] Does this emphasis on the vertical and horizontal straight lines have any basis in physiology? Physiological recordings have failed to identify a preponderance of cells that respond to the vertical and the horizontal orientation. But perceptual experiments show that these two orientations are indeed the easiest to see.[20] Perhaps, in spite of the fact that an army of physiologists has been studying orientation selectivity for the past 30 years, we have simply not sampled a sufficient number of cells from among the billions to be able to draw an adequate conclusion in physiological terms.

lls on the part of the visual
that orientation 'looks at'.
tion selective cells provide
hat neurology is not ready
cells are lost by not being
the critical period or as a
duced by vascular or other
otherwise, of the work of
e emphasised, is possible.
ve a very wide distribution
reas, there are no reported
ons, patients are selectively
e is a severe condition in
onoxide poisoning[17] or a
deprive the brain of oxy-
ef period,[18] become virtu-
ours (see also chapter on
they can see the colour
ian and Malevich, have no
which quite simply do not
he work of Mondrian, and

bout the orientation of the
curved line was as nothing
Highly irritated by the fact
of the De Stijl group, used
hat, 'Following the high-
ed the diagonal, all further
mpossible. For the rest, *sans*
tical and horizontal straight
ysiological recordings have
lls that respond to the ver-
ut perceptual experiments
ndeed the easiest to see.[20]
y of physiologists has been
e past 30 years, we have
er of cells from among the
conclusion in physiological

There is an additional interest in parallel oriented lines, a feature of some of the creations of Barnett Newman, Robert Ryman, and Jack Bush among others. Depending upon the distance from which they are viewed and hence the angle subtended at the eye, these oriented lines can activate one or many cells simultaneously. This is by virtue of a feature known as the frequency grating preference of a cell, a high sounding term which means the width preference. Some cells prefer very narrow lines while others prefer wider ones. Hence, viewing a painting by Barnett Newman might stimulate one group of cells selective for the orientation depicted in the painting, while not stimulating another group of cells that are selective for the same orientation but a different width. Again, this is not to say that the activation of highly specific groups of cells is what leads to the aesthetic experience but only that such aesthetic experience is not possible without these cells.

Mondrian had an abhorrence not only for the diagonal line, but for the curved line as well, writing that the curved line resolves itself into a straight line. This is not the view shared by other artists who have emphasised lines. Robert Mangold's creations, for example, contain not only diagonal lines but curves as well. The diagonal element is relatively easy to account for neurobiologically, in that there are many cells in the cortex that respond selectively to diagonal lines. The curved line presents a greater problem. No one has yet discovered cells that respond specifically to curved lines. The physiologist's answer to this problem is straightforward, but it is also a little glib. He assumes that a tangent through any given part of the circle forms a straight line, with an orientation corresponding to the orientational preference of some cells. To him, like to Mondrian, the curved line resolves itself into a straight line. But this does not address the question of how the brain distinguishes between straight and curved lines, which remains a neurophysiologically unsolved problem.

It is in many ways remarkable that, in their search for the constituents of forms, many artists have come up with the same answer as physiologists in their search for the physiological 'building blocks' of forms. This may of course be regarded as nothing more than fortuitous. But it is worth nevertheless reflecting about.

---

1. Apollinaire, G. (1986). *Les Peintres cubistes: Méditations esthétiques*, Berg

International, Paris. Apollinaire does not use the term *Einfühlung*.

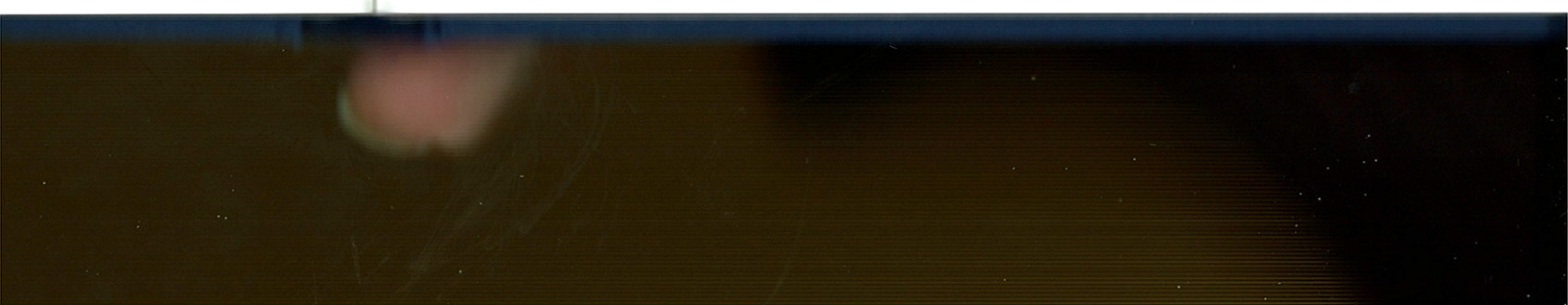
2. The notion of *Einfühlung* in art was first elaborated by the German philosopher Robert Vischer in a work entitled *Über das Optische Formgefühl*. Wilhelm Worringer developed the notion further and applied it to abstract art in his doctoral thesis at Berne University, published in 1908, which was entitled *Abstraktion und Einfühlung*, but Worringer sought other, non-neurobiological, explanations for the then developing abstract art. See D. Vallier (1980). *L'Art abstrait*, Hachette, Paris.
3. Michel Hoog in *Cézanne ou la peinture en jeu*, quoted by Gilles Plazy (1988). *Cézanne ou la peinture absolue*, Liana Levi, Paris 1998.
4. Fry, R. (1958). *Cézanne and His Development*, The Noonday Press, New York.
5. Gabo, N. (1959). *Of Divers Arts*. The A.W. Mellon Lectures in the Fine Arts, National Gallery of Art, Washington. Pantheon Books, Bollingen Foundation, New York.
6. Mondrian, P. (1937). *Plastic Art and Pure Plastic Art*, from The Circle 1937, reproduced in Mondrian, From Figuration to Abstraction, catalogue of the Mondrian Exhibition, 1987–88, Thames and Hudson, London.
7. Mondrian, P. (1941). Toward the true vision of reality. In *The New Art – The New Life, The Collected Writings of Piet Mondrian* (edited and translated by H. Holtzman and M. S. James), G.K. Hall & Co., Boston, 1986, pp. 338–41.
8. Mondrian (1937). *Plastic Art and Pure Plastic Art*, loc. cit.
9. Mondrian, P. (1919). Dialogue on the New Plastic. In *The New Art – The New Life*, pp. 75–81, loc. cit.
10. Mondrian (1937). *Plastic Art and Pure Plastic Art*, loc. cit.
11. Kahnweiler, D-H. (1946). *Juan Gris. Sa Vie, son oeuvre, ses écrits*, Gallimard, Paris.
12. Gleizes, A. and Metzinger, J. (1913). *Cubism*, Fisher Unwin, London.
13. Golberg, M. (1908). *La Morale des lignes*, quoted by E. C. Oppler (1976) in *Fauvism Re-examined*, Garland Publishing, New York.
14. Aubery, P. (1965). Mécislas Golberg et l'art moderne, *Gazette des Beaux Arts*, **66**, 339–44.
15. Hubel, D. H. and Wiesel, T. N. (1959). Receptive fields of single neurons in the cat's striate cortex, *J. Physiol. Lond.*, **148**, 574–91.
16. Proust, M. (1922). *Contre Sainte Beuve*. Bibliothéque de la Pléiade, Gallimard, Paris.
17. Wechsler, I. S. (1933). Partial cortical blindness with preservation of color vision. *Archs. Ophthalmol.*, **9**, 957–65.
18. Humphrey, G. K., Goodale, M. A., Corbetta, M. and Aglioti, S. (1995). The McCollough effect reveals orientation discrimination in a case of cortical blindness, *Current Biology*, **5**, 545–51.
19. Mondrian, P. quoted in Seupher, M. (1956), *Piet Mondrian: Life and Work*, H. N. Abrams, New York.
20. Campbell, F. W. and Kulikowski, J. J. (1966). Orientational selectivity of the human visual system, *J. Physiol.*, **187**, 437–45.

13

Mondrian, Ben Nicholson, Malevich and the neurophysiology of squares and rectangles

When straight vertical and horizontal lines intersect, they define squares or rectangles—Mondrian thought that the whole complex of forms could be reduced to 'the plurality of straight lines in rectangular opposition'.[1] In reducing all forms to their essence—the straight line—and thus achieving the destruction of particular forms, art had, Mondrian believed, uncovered another universal constituent of forms, that of determined relations specified by free lines. 'Through the clarity and simplicity of neutral forms, non-figurative art has made the rectangular relation more and more determinate, until, finally, it has established it through free lines which intersect and appear to form rectangles'.[2] Malevich, from the perspective of 'non-objective art', reached much the same conclusion and emphasised squares and rectangles in his drawings. Both, together with the Synthetic Cubists, thought that they were creating new forms, forms not seen before, and thus creating new realities. The taste for the rectangle and the square did not die with them. It was popular with many artists, including Van Doesburg, Ben Nicholson, Ellsworth Kelly, Robert Ryman and Ad Reinhardt, to mention a few among many others (Figure 13.1). To the uninitiated eye, there is little difference between the Malevich paintings that emphasise squares and the corresponding paintings of, say, Ben Nicholson although both artists would no doubt be outraged at such an equation.

Physiologists have not explicitly thought of squares and rectangles as the building blocks of form, but in comparing some of



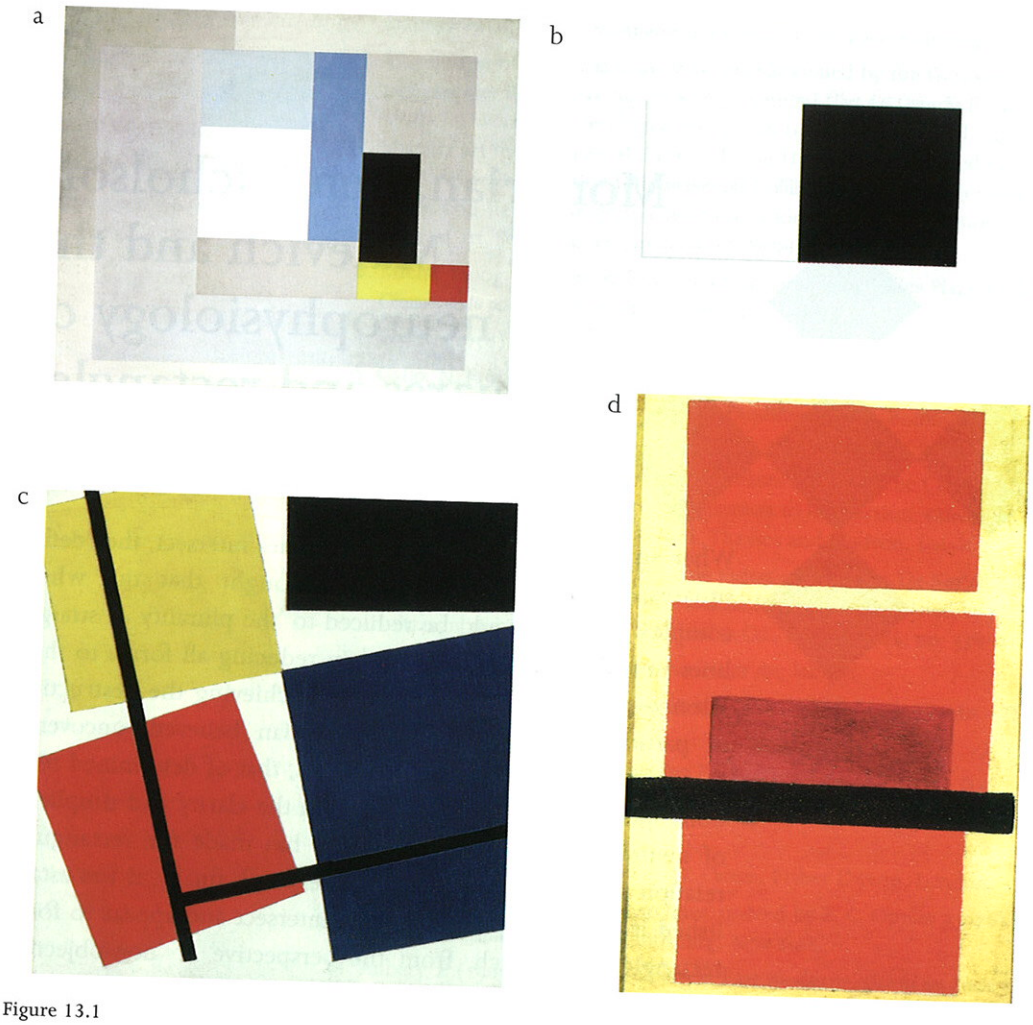


Figure 13.1

(a) Ben Nicholson, *Painting 1937* (© Tate Gallery, London 1998. © Angela Verron-Taunt/All rights reserved, DACS 1999). (b) Ellsworth Kelly, *White and Black* (© 1973, Ellsworth Kelly/Gemini G.E.L, Courtesy of Gemini G.E.L., Los Angeles, California); (c) Theo Van Doesburg (C. E. M. Küpper). *Simultaneous Counter-Composition.* (1929–30) Oil on canvas, $19\,^{3}/_{4} \times 28\,^{5}/_{8}$" (50.1 × 49.8 cm). The Museum of Modern Art, New York. The Sidney and Harriet Janis Collection. Photograph © 1999 The Museum of Modern Art, New York. (d) Olga Rozanova, *Non-objective Composition* (State Russian Museum, St Petersburg).

the creations of artists with the physiology of single cells in the cortex, it is interesting to describe the shape of the receptive fields in the visual brain and particularly, though not exclusively, in area V4. The receptive field of a visual cell may be very small, as it is in V1, or it may be relatively large, as it is in V4. But whether large or small, receptive fields are usually square or rectangular in shape. It is only when the appropriate visual stimuli are flashed within these square or rectangular receptive fields that cells will respond. The appropriate stimulus differs from cell to cell, as mentioned before, but one can make a general statement by saying that there has to be some kind of transformation between what is in the receptive field and what is in the surround. This

transformation may take any of a different number of characteristics but each cell is specific for a particular kind of transformation. A cell might then be said to respond to a transformation in energy between one part of its receptive field and another. Some cells respond only when the transformation in energy between the stimulus and its surrounds is so disposed as to create a vertically oriented line. For others, there must be a transformation in colour.

A cell with the latter characteristics is shown in Figure 13.2. This cell responded optimally to a blue square against a white background, but was almost unresponsive to the same square presented against a black background. Its receptive field properties, when drawn out as in Figure 13.2, look remarkably similar to the Malevich tableau shown below it in the same figure. One would be foolish to equate the two, to pretend that the 'non-objective sensation' that led to the 'non-objective art' so favoured by Malevich is what led him to paint a receptive field! The similarity between the two is nevertheless compelling and one can say with near certainty that the Malevich work would not produce any aesthetic effects but for the presence of these cells, which is not the same thing as saying that they alone produce the aesthetic effects. If one were to view the Malevich painting from a distance that is sufficiently large, then the entire square in the Malevich painting could fall onto the receptive field of a single cell like the one illustrated in Figure 13.2. Here it is important to emphasise that no one would consider the perception of the configuration shown in the Malevich painting or the configuration shown in Figure 13.2, which actually activates a cell in area V4, to be due to the activity of a single cell; rather, there are many cells that have similar properties, so that if one of them were to die many would remain. Whether activation of a single cell can lead to perception is a question that neurology has no answer to yet; I would not find it outrageous if this were to be the case, but it is more likely that the activity of many cells with similar response properties is involved.

Another example may be found in the blue squares of the painting by Theo van Doesburg entitled *The Cow* (Figure 13.3). The composition consists of many squares of different colour, the immediate background of each being white. Consider the blue square in the upper left hand corner, which is surrounded by

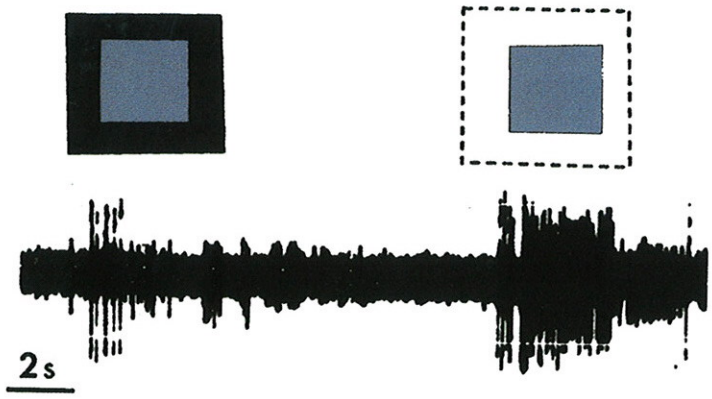
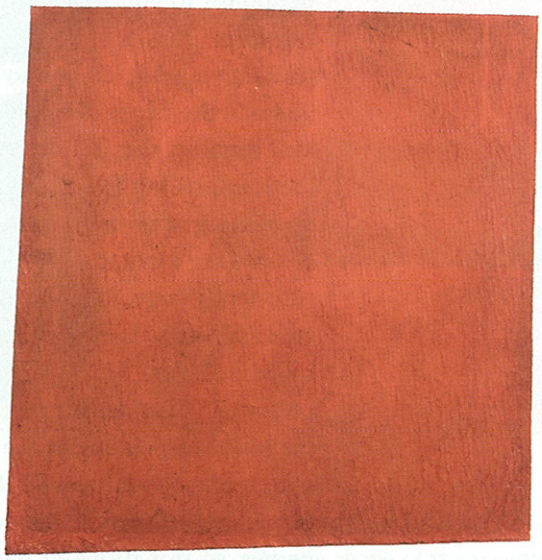


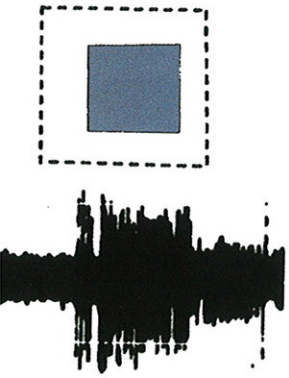
Figure 13.2

Below: Kazimir Malevich, *Red Square* (© The State Russian Museum, St Petersburg). Above are shown the responses of a cell in area V4 to a blue square. The cell prefers a blue square against a white background (right) to one against a black background (left).



white. Looked at in isolation from the rest of the picture, this blue square shares a strong similarity with the kind of configuration that excites the cell of V4 shown in Figure 13.2—a blue square against a white background, but not against a black background.

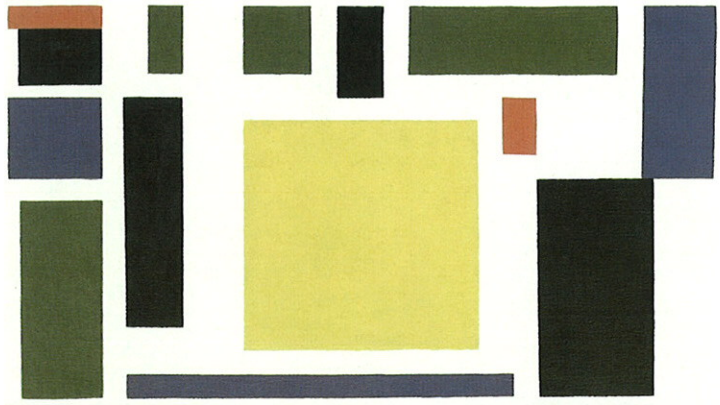
Such examples may be multiplied many times over, but I think that the similarity between the two, the receptive field structure and characteristics of a cell on the one hand and the creations of



rest of the picture, this blue
the kind of configuration
igure 13.2—a blue square
gainst a black background.
nany times over, but I think
he receptive field structure
hand and the creations of

Figure 13.3

Theo Van Doesburg (C. E. M. Küpper). *Composition (The cow)*. (c. 1917) Oil on canvas, $14^{3}/_{43} \times 25''$ (37.5 × 63.5 cm). The Museum of Modern Art, New York. Purchase. Photograph © 1999 The Museum of Modern Art, New York.



artists such as Malevich on the other, is really quite striking. This relationship is made all the more compelling when one reflects that the painting is the creation of a brain that contains cells with the kind of receptive field described above.

If we consider this further, we shall find that, though we can seek for a direct explanation for the perception of some of these creations in the physiology of single cells in the visual cortex, they also have features not so easily accounted for, which is not the same thing as saying that we may not be able to do so in the future, near or distant. I would guess that a cell in the visual brain that responds to a black square against a white background would respond equally well to a uniform black square and a black square that contains one or more other black squares or rectangles, so faint in appearance that they are not readily distinguishable, at least not from a distance. The primary function of the cells that I have described above is to register the difference between one part of the receptive field and an adjoining part, between the very dark part and the lighter part. No one has yet described cells that are capable of registering consistently such small transitions in intensity, as are sometimes found in the squares that form so ubiquitous a characteristic of the work of Josef Albers (Figure 13.4) or of the white square against a white background of Malevich. Equally, one can well imagine that a cell that responds vigorously to a red square on a white or black background would also respond vigorously to one of Ad Reinhardt's red paintings, but no one has yet discovered a cell that would modulate its responses to the tiny differences in the quality and intensity of red

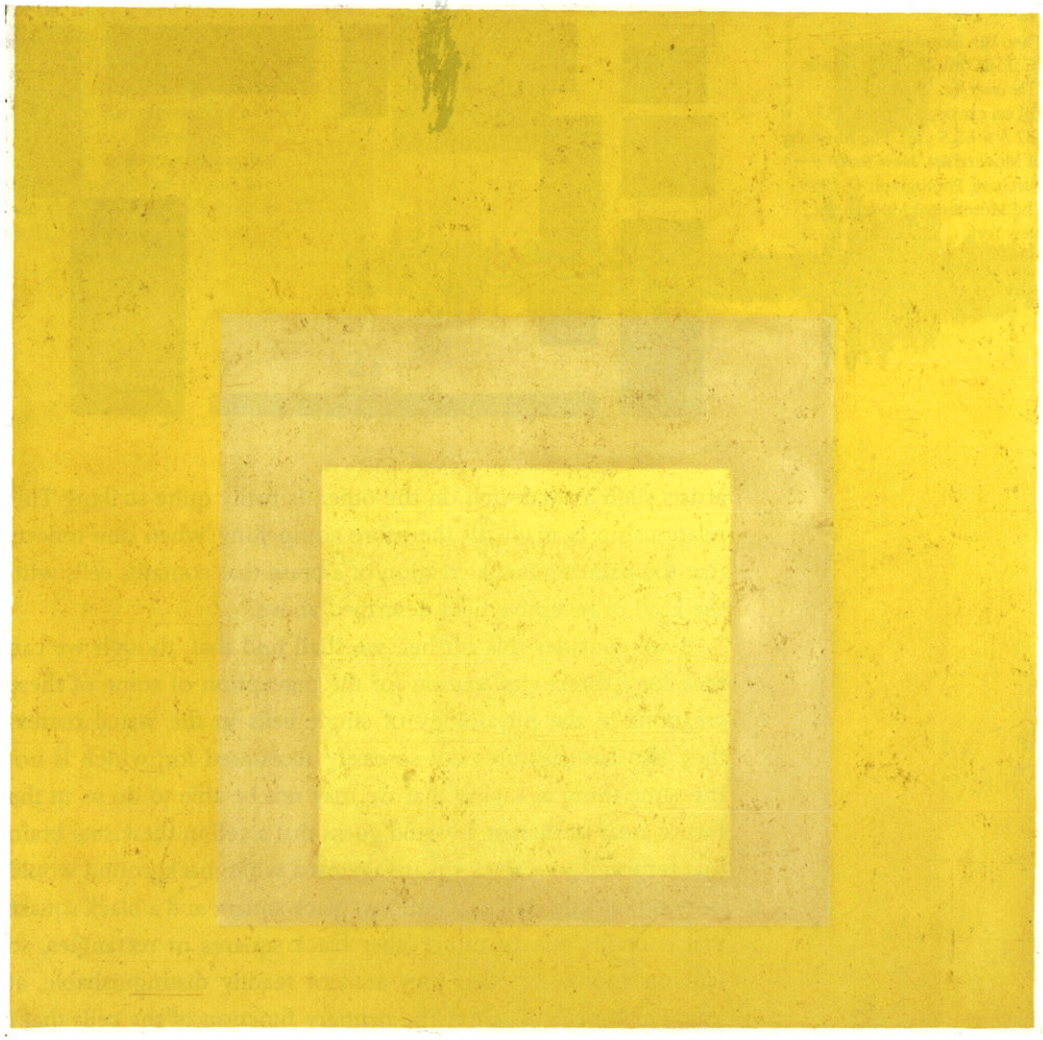


Figure 13.4

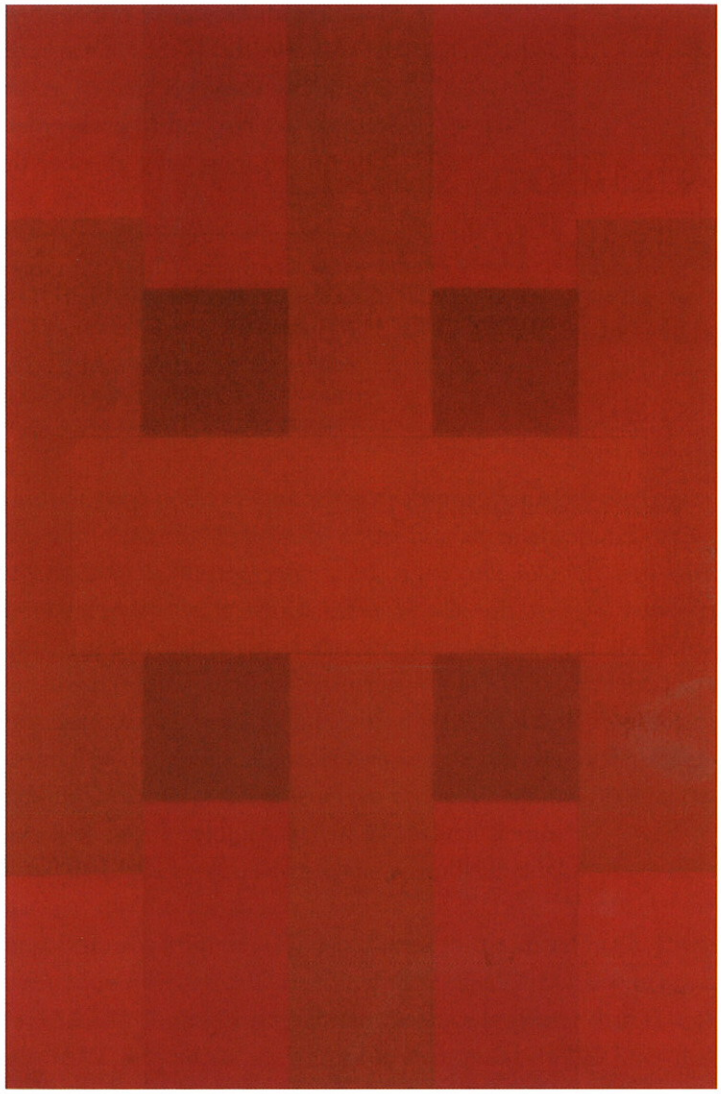
Josef Albers, *Homage to the Square: Yellow Climate* (Louisiana Museum of Modern Art, Humlebaek, Denmark).

that the smaller red squares and rectangles within the larger red square of Reinhardt have (Figure 13.5).

Mondrian emphasised many times that the rectangular forms created by the 'plurality of straight lines' could not be haphazard—there was a configuration that was serene, 'free of tension'. That configuration was presumably reached by trial and error. But who was the judge of that serenity? There is no objective judgement, and hence we can only assume that Mondrian himself, or more properly his brain, decided that the right configuration, free of tension, had finally been reached. But are these really new forms, as Mondrian and Malevich and the Synthetic Cubists have

ngles within the larger red
).
that the rectangular forms
nes' could not be haphaz-
as serene, 'free of tension'.
ched by trial and error. But
here is no objective judge-
that Mondrian himself, or
he right configuration, free
But are these really new
the Synthetic Cubists have

Figure 13.5
Ad Reinhardt, *Red Abstract* (Collection Yale University Art Gallery, New Haven).



claimed? Or are they more properly the 'pre-existent idea which is within us' that Gleizes and Metzinger, with greater neurological insight, believed? The fact is that the new forms, consisting largely of lines, squares and rectangles, are admirably suited to stimulate cells in the visual cortex, and the properties of these cells are, to an extent, the pre-existing 'idea' within us.

While one cannot draw an exact causal relationship between the two, one can state with certainty that when we look at the paintings of Malevich, many cells in our brain with the characteristics

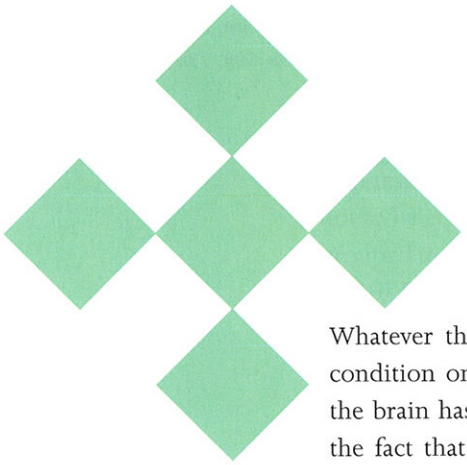
illustrated above will be responding vigorously. One can also state the converse, that if cells in the brain did not respond to this kind of stimulus, then this kind of art would not exist. The cells in the brain do not respond to ultra-violet light and ultra-violet art does not exist. Art must, after all, obey the laws of the brain.

---

1. Mondrian, P. (1941). Toward the true vision of reality. In *The New Art—The New Life, The Collected Writings of Piet Mondrian* (edited and translated by H. Holtzman and M. S. James), G. K. Hall & Co., Boston, 1986.
2. Mondrian, P. (1937). *Plastic Art and Pure Plastic Art*, from The Circle 1937, reproduced in *Mondrian, From Figuration to Abstraction, Catalogue of the Mondrian Exhibition*, 1987–88, Thames and Hudson, London.

15

The neurophysiology of the *MétaMalevich* and the *MétaKandinsky*



Whatever their constituents, forms are rarely seen in the static condition only; they are commonly in motion. In this instance, the brain has to extract knowledge about a form even in spite of the fact that it is in motion. The motion may be of two kinds, either the actual motion of the form itself or the displacement of the image on the retina by the movement of the eyeballs. This makes it interesting to consider the creations of some artists who have set forms into motion, in relation to how the orientation selective cells in the brain respond to motion.

The kind of orientation selective cell that we have so far been considering is one that responds to a line of the appropriate orientation, regardless of its colour, when that line is flashed in the receptive field of the cell. The appropriate line may be flashed on and off, without moving. Whenever it is flashed on, the cells give a vigorous discharge. That is an adequate description of many, but not all, orientation selective cells in the visual cortex; many more respond far better when a line of their preferred orientation is moved back and forth across the receptive field in a direction orthogonal to the orientation of the line. Some of these orientation selective cells are even more exigent in their requirements, responding to a line of the appropriate orientation but only if it is moving in one direction and not in the opposite, null, direction. They are said to have the property of directional selectivity in addition to their orientation selectivity. Such cells are an especially prominent group in one of the visual areas constituting the third visual complex (areas V3 and V3A), though they are not

15

ophysiology MétaMalevich MétaKandinsky

re rarely seen in the static
n motion. In this instance,
out a form even in spite of
tion may be of two kinds,
tself or the displacement of
ement of the eyeballs. This
eations of some artists who
on to how the orientation
motion.
ell that we have so far been
line of the appropriate ori-
n that line is flashed in the
iate line may be flashed on
is flashed on, the cells give
ate description of many, but
e visual cortex; many more
eir preferred orientation is
ceptive field in a direction
ine. Some of these orienta-
gent in their requirements,
te orientation but only if it
n the opposite, null, direc-
ty of directional selectivity
vity. Such cells are an espe-
visual areas constituting the
V3A), though they are not

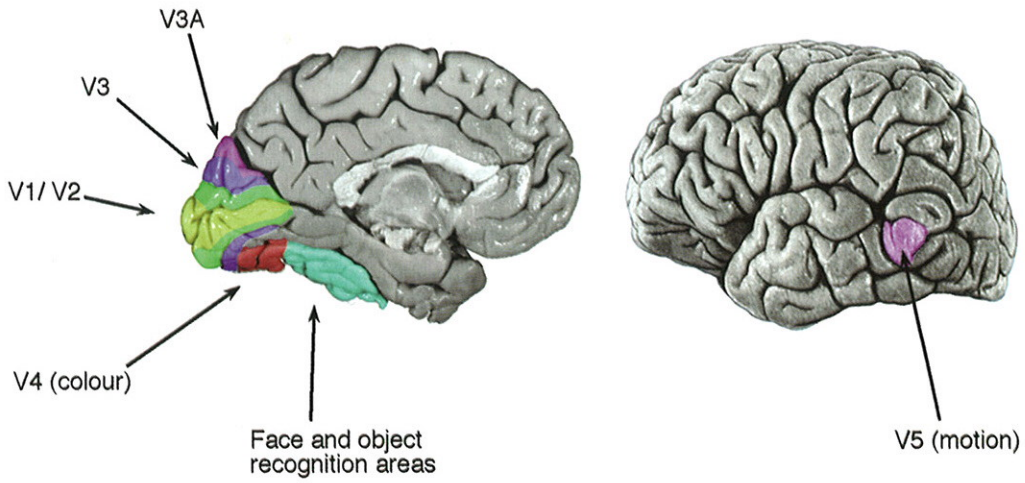


Figure 15.1
The location of visual areas in the human cortex.

unique to these areas. The position of these visual areas in the human brain has been defined, and is shown in Figure 15.1.

One could make a convincing argument that oriented lines constitute an important element of most paintings; the oriented lines constituting the spears are obviously an important and readily discernible feature of the works of Uccello. But any painting in which there are multiple boundaries—which is to say all paintings—have oriented lines embedded in them even if these are not perceptually always explicit. When the eye fixates point X in looking at Velazquez's *Toilet of Venus* (Figure 15.2), the individual cells of V1, V2 and V3, which undertake a piece-meal analysis of the visual world, will be excited by the small segments of the boundaries shown, assuming that these boundaries have the correct orientation for these cells. A similar analysis can be undertaken in respect of almost any painting. But in the work of Malevich, Mondrian and Barnet Newman, among others, the oriented lines are not parts of boundaries—they are free and perceptually explicit; indeed they constitute the cornerstone of the paintings themselves.

When we view a work by Malevich, and others, in which oriented lines form a predominant element, the lines will be strong stimuli for activating the orientation selective cells of the visual cortex. But these lines are usually stationary; they will not therefore activate all the orientation selective cells optimally because many respond poorly to stationary oriented lines and their response is much improved if the oriented lines are set in motion.

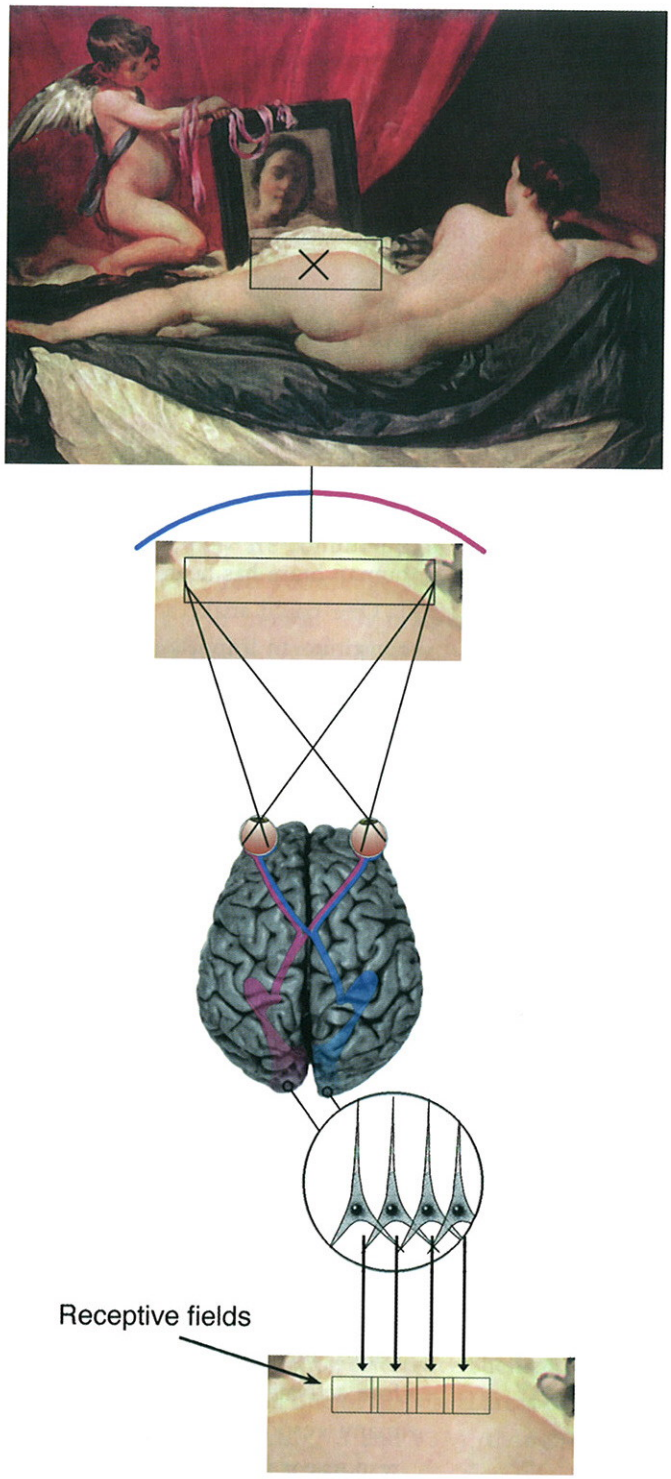
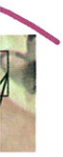


Figure 15.2

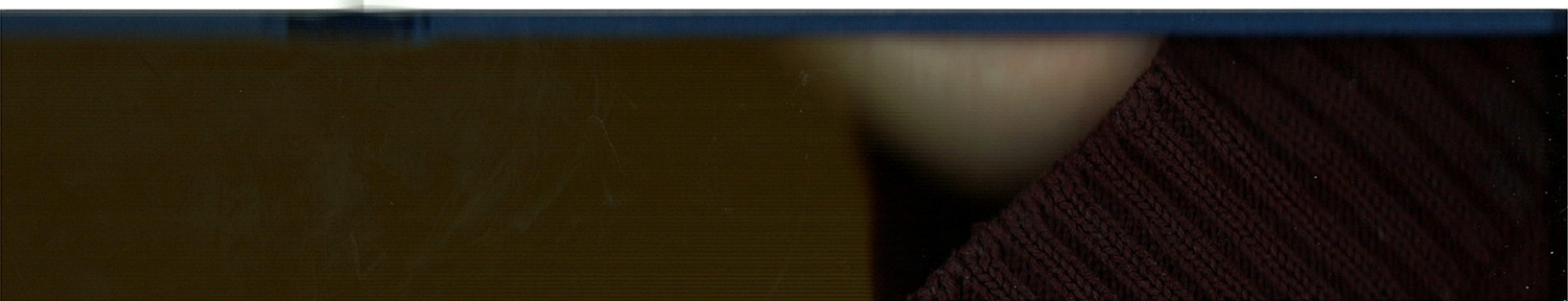
The problem in perceiving segments of Velazquez's *Toilet of Venus* (*The Rokeby Venus*) (© National Gallery, London).



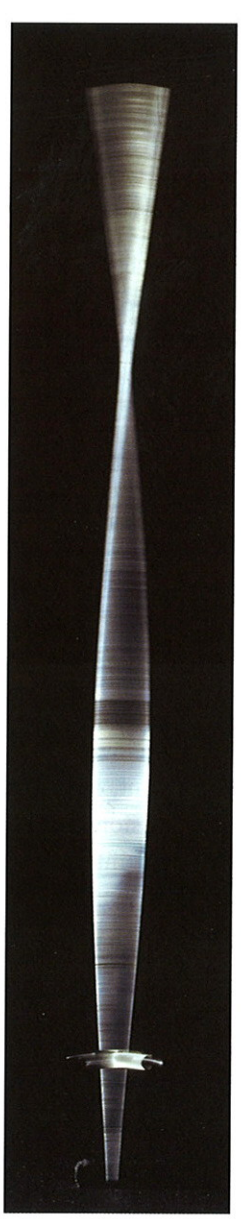
It was the Swiss artist Jean Tinguely who conceived the interesting idea of taking a work such as Malevich would execute, and setting the oriented lines and edges in it in motion; the result was a *MétaMalevich* or a *MétaKandinsky*. Without ever realising it, Tinguely had succeeded in tailoring one aspect of his art to the physiology of orientation selective cells in the cortex, the ones that respond best when the oriented lines are set in motion.

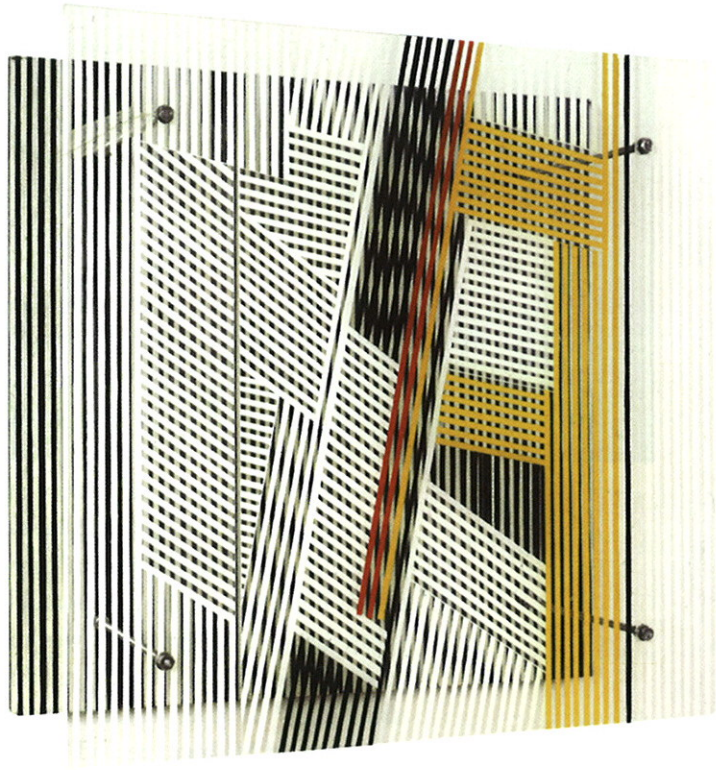
Tinguely tells us that he became impressed by motion after seeing the French painter Georges Mathieu work. He recounts how he used to watch Mathieu paint, and how it was Mathieu's movements, while painting, that fascinated him. Once finished, Mathieu's work ceased to have any fascination for Tinguely, for the movement had ceased. It was, in brief, the element of motion that most attracted the visual cortex of Tinguely, though that is not quite the way he explained it. He said, 'I didn't know how to stop a painting ... I simply couldn't get to the point of saying, "Okay, that's finished" ... That's basically what made me start to work with movement. Movement was an escape from the petrification, the ending. You could say it allowed me to say "Okay, that's finished."'[1] In other words, movement had gained primacy in his thinking. Of Mathieu, he said 'Stop evoking movements and gests. You are the movement and the gest.'[2] Movement, its beginning and its cessation, must have made a deep impression on Tinguely. It was from such beginnings that he developed into one of the principal figures of kinetic art.

As we shall see in the next chapter, kinetic art has also tended towards simplification and, in the process, become better and better tailored to the physiology of single cells in the cortex. Tinguely's *MétaMalevichs* and *MétaKandinskys* represent but one stage in the evolution of that art, but it is a physiologically significant step. In fact, Tinguely's work was anticipated to some extent by the kinetic sculpture of the Russian artist and intellectual Gabo. In spite of the high sounding titles and the somewhat assertive affirmations of the *Manifesto of Futurism* in which Gabo and his brother Antoine Pevsner proclaimed, somewhat shrilly, the importance of movement in a work of art, they, like others of the time, did little to introduce actual motion into art. An important exception, and the precursor of much in modern kinetic art, was Gabo's *Kinetic Sculpture* (Figure 15.3a). This was basically a simple form, a straight line, which could be set into motion; it did not



a





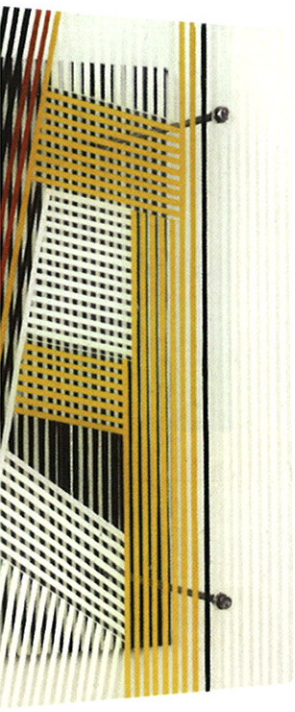
b

Figure 15.3

(a) Naum Gabo, *Kinetic Sculpture* (© Tate Gallery, London 1998); (b) Jesús Rafaël Soto, *Dynamics of Colour* (artist's collection).

exalt motion to the extent that Gabo had implied in his *Manifesto*, but it anticipates many more recent works in which motion is an integral part, including the kinetically more vibrant works of Hugo Demarco (e.g. his *Series Relations* of 1988) and of Jesús Rafaël Soto (Figure 15.3b). *Kinetic Sculpture* was exhibited in 1922 in Berlin, with a catalogue note that read '*Time as a new element in plastic art*'.[3] It was not much later, in 1926, that the Hungarian artist and inventor of the fountain pen, Laszlo Moholy-Nagy, started to design his Light Machine, *Licht-Raum-Modulator*.[4] During the same period, he completed his *Light-Prop for an Electric Stage* (Figure 15.4).

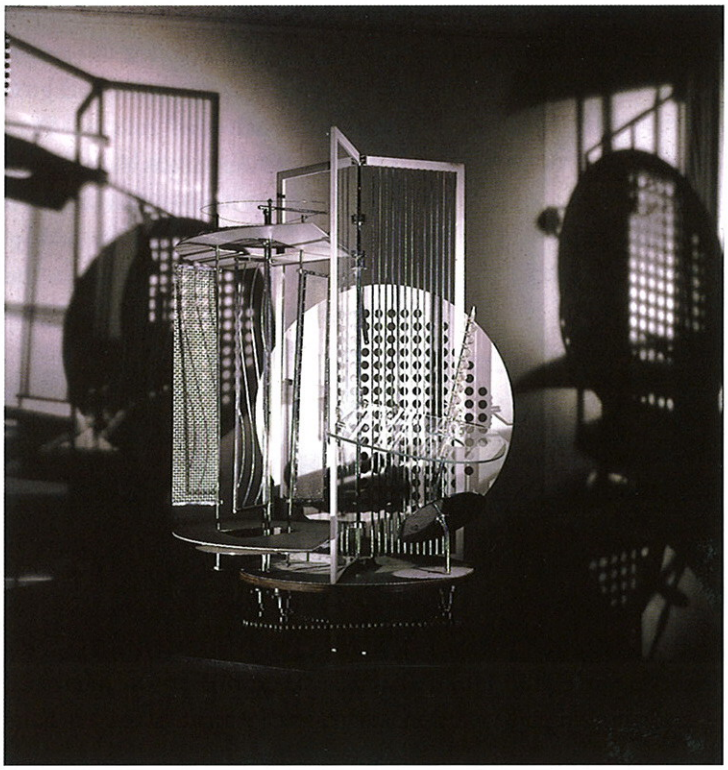
In addition to the motion of the component parts, the use in this kinetic sculpture of moving mirrors which reflected moving light in all directions did much to enhance the motion effect



ıdon 1998); (b) Jesús Rafaël Soto,

ıad implied in his *Manifesto*,
ɔrks in which motion is an
ɣ more vibrant works of
f 1988) and of Jesús Rafaël
vas exhibited in 1922 in
'*Time as a new element in plastic*
at the Hungarian artist and
Moholy-Nagy, started to
Modulator.[4] During the same
n *Electric Stage* (Figure 15.4).
ɔmponent parts, the use in
rs which reflected moving
ɛnhance the motion effect

Figure 15.4
Laszlo Moholy-Nagy, *Licht-Raum-Modulator*, 1930 (© The Stedelijk Van Abbemuseum, Eindhoven).



produced by the sculpture; the many oriented edges produced by both the objects and the mirrors would entail a powerful stimulation of cells in area V3. Tinguely's innovation lay really in his returning to the early stages of kinetic art, to Gabo's *Kinetic Sculpture*, emphasising simple shapes—squares, rectangles and so on—and putting them in motion. He was, without ever having realised or even thought of it, tailoring his art to the physiology of cells in the brain that are responsive to oriented lines and edges in motion. It is difficult to imagine stimuli that are better suited to excite the orientation plus motion (including the direction) selective cells of the visual brain, and especially of area V3, than some of the shapes contained in Tinguely's work and in the later work of Jesús Rafaël Soto and others, which also emphasise oriented lines in motion. It is obvious that Gabo, Tinguely and others were not influenced at all by the results of physiological experiments, for the *MétaMalevichs* were constructed some years before orientation selective cells were discovered in the cortex. Later, in the mid-1960s, Tinguely executed his *Métamécaniques*,[5] which reached new heights in physio-

logical terms, and contained stimuli which physiologists could hardly have bettered. The motion of the oriented lines, most of them white against a black background, is optimal for stimulating orientation selective cells in V1 and V3. For good measure, Tinguely's *Métamécaniques* also contain white circular patches against a black background—ideal stimuli for activating some of the cells in V1. In brief, without ever having realised it, Tinguely seems to have known how best to activate the cells of V1, V3 and V3A.[6] It is interesting that Tinguely reduced his palette too, and made most of the simple shapes in black or white, against a neutral background. In fact the orientation plus direction selective cells in the cortex are indifferent to the colour of the stimulus; they would therefore respond equally well to an appropriately oriented line of any colour. Hugo Demarco's kinetic sculpture entitled *Horizontal and Vertical Movement* (Figure 15.5) is an even more powerful stimulator of the orientation selective cells in the brain: it consists of a series of vertical and horizontal lines of different colour that move upwards and downwards, changing their colours as they do so. The oriented lines will stimulate the cells of areas V3 and V3A

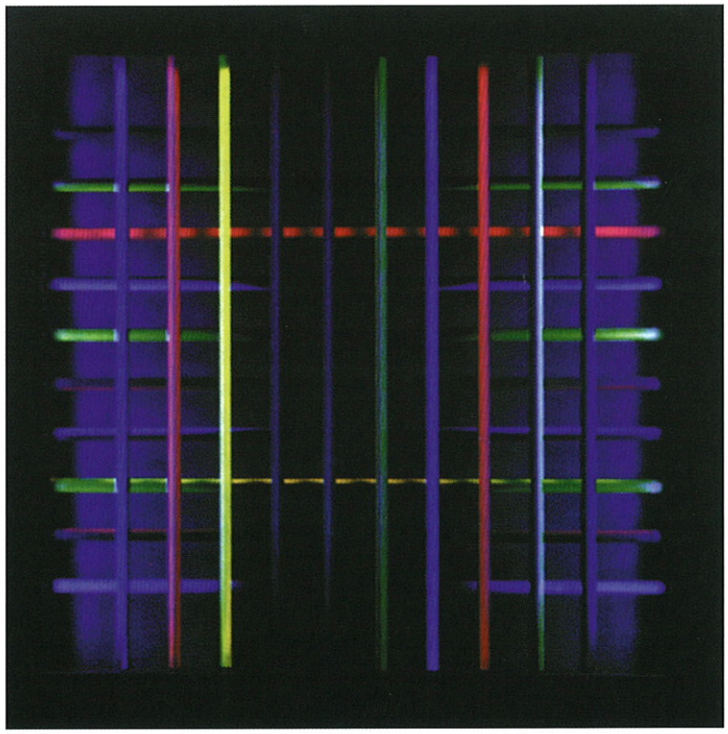
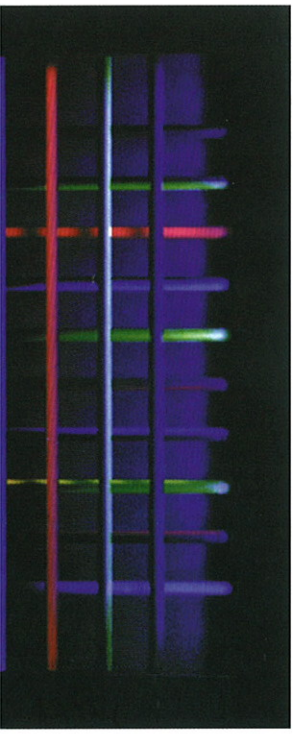


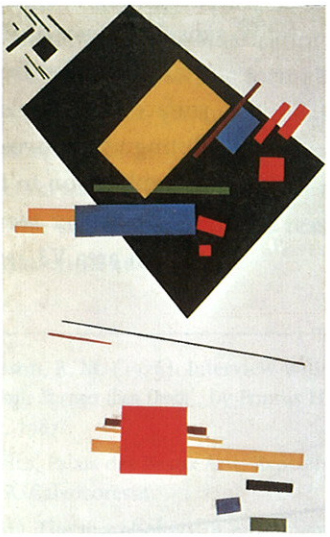
Figure 15.5
Hugo Demarco, *Horizontal and Vertical Movement* (artist's collection).

vhich physiologists could
ne oriented lines, most of
, is optimal for stimulating
V3. For good measure,
ite circular patches against
ctivating some of the cells
lised it, Tinguely seems to
lls of V1, V3 and V3A.[6] It is
ette too, and made most of
inst a neutral background.
ective cells in the cortex are
lus; they would therefore
tely oriented line of any
ture entitled *Horizontal and*
more powerful stimulator
rain: it consists of a series
fferent colour that move
eir colours as they do so.
cells of areas V3 and V3A



powerfully, even in spite of the variation in colour, because these orientation selective cells are indifferent to the colour of the oriented lines, their preoccupation being with the orientation alone. We shall see in the next chapter, however, that there may be sound physiological reasons for rendering these forms in monochrome, as Tinguely was to do.

Moving oriented lines have been used in many works of art. But other, non-kinetic, works of art have also capitalised on ori-



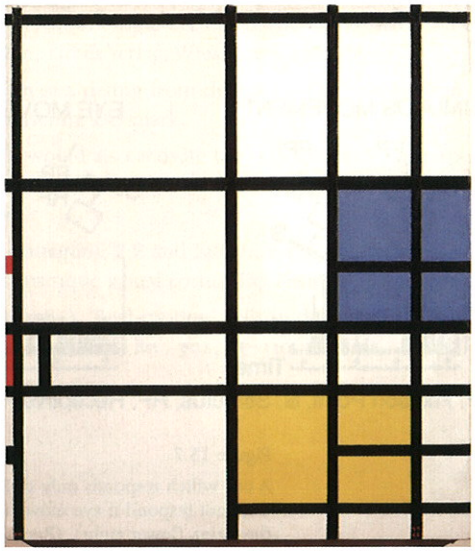


Figure 15.6

Top: Kazimir Malevich, *Suprematist Composition* (Stedelijk Museum, Amsterdam/Bridgeman Art Library, London/NewYork), bottom: Piet Mondrian, *Composition London* (© Mondrian/ Holtzman Trust, c/o Beeldrecht, Holland and DACS, London), Albright-Knox Gallery, Buffalo, New York.

ented lines, the work of Mondrian, Malevich and Sonia Delaunay (Figure 15.6) being but three examples among many. It therefore becomes interesting to ask how the brain resolves the difference between the oriented lines in a Malevich tableau and the oriented lines in a *MétaMalevich*, the latter being in motion while the former are stationary.

When we look at a painting and fixate its different parts, our eyes are never totally immobile. In addition to the small tremors known as saccades, our eyes move to scrutinise different parts of a region of interest. The consequence of that eye movement is to displace the retinal position of the image. But this displacement is quite different from the actual displacement of the object or surface in our field of view, as in a *MétaMalevich*. We can, after all, distinguish between the two. And if we can do so, we must seek an explanation in terms of brain activity.

The answer seems to lie in the way that orientation selective cells in area V3 respond (Figure 15.7). Here some cells, which

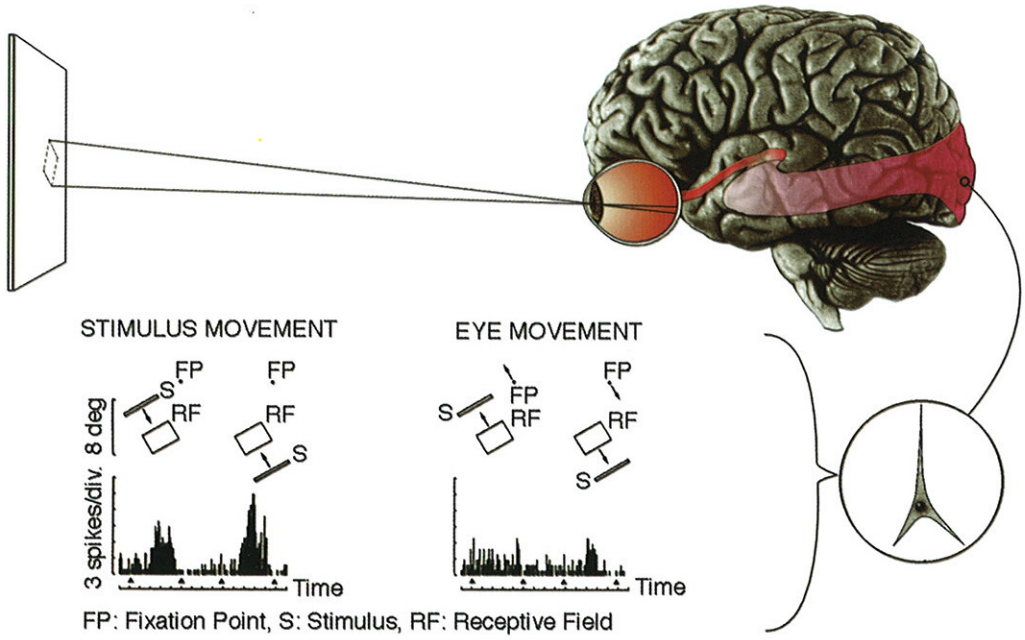


Figure 15.7

A cell which responds only if the stimulus itself is actually moving (lower left). It does not respond if eye movements alone produce the displacement of the image on the retina (lower right). (Reproduced with permission from Galletti *et al.* 1990.)[9]

levich and Sonia Delaunay
among many. It therefore
ain resolves the difference
h tableau and the oriented
motion while the former

ate its different parts, our
ition to the small tremors
crutinise different parts of
f that eye movement is to
e. But this displacement is
cement of the object or
aMalevich. We can, after all,
can do so, we must seek
y.
that orientation selective
. Here some cells, which

ctually moving (lower left). It
he displacement of the image on
on from Galletti *et al.* 1990.)[9]

have been termed the 'real motion cells',[7] are capable of distinguishing between the motion of the stimulus itself and the motion of the eye, which has the same effect of displacing the position of the image of the stimulus on the retina of the eye. Presumably, the real motion cells of area V3 are a good deal more complex in their behaviour because they receive not only visual signals but also information about eye position, and are able to discount the latter.

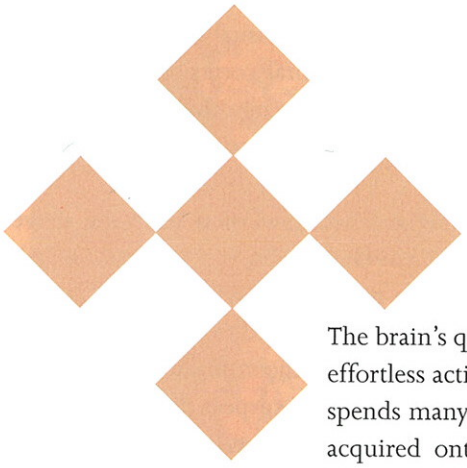
Whatever the detailed wiring that leads to the emergence of cells with such sophisticated properties, it is apparent that the transition from the Malevich to the *MétaMalevich* and the *Métamatique* involves more than a change in artistic form; it involves the activation of distinct, and different, groups of cells in the visual brain. This is but another example in a more general theme that runs throughout this book: that different forms of art excite different groups of cells in the brain, which is one reason why there is a functional specialisation in aesthetics.

---

1. Georg, C. and Mason, R. M. (1976). Interview with Jean Tinguely, reprinted in '*A Magic Stronger than Death*', by Pontus Hultén, Thames and Hudson, London, 1987.
2. Catalogue, Bruxelles, Palais des Beaux Arts, Exposition de 1982–1983. Commentary by R. Calvocoressi.
3. Rickey, G.W. (1963). The morphology of movement: a study of kinetic art, *Art Journal*, **22**, 220–31.
4. Ramsbott, W., 'Chronologie der kinetischen kunst nach 1900' in '*Movens*' by Franz Mon, Limes Verlag, Wiesbaden, 1960.
5. Two *Métamécaniques*, dating from the mid-1960s, can be seen at the Louisiana Museum, Denmark.
6. Such stimuli would also activate the cells of area V2, interposed between V1 and the other visual areas, but this need not concern us further here.
7. Galletti, C., Battaglini, P. P. and Fattori, P. (1990). Real-motion cells in area V3A of macaque visual cortex, *Exp. Brain Res.*, **82**, 67–76.
8. Galletti *et al.* (1984). 'Real-motion' cells in the primary visual cortex of macaque monkeys. *Brain Res.*, **301**, 95–110.

21

Monet's brain



The brain's quest for visual knowledge of the world is a seemingly effortless activity. In pursuit of the same aim, the artist by contrast spends many hours in distilling the knowledge that his brain has acquired onto canvas. In this process, higher mental activities intervene. A good example is the combination of a visual and intellectual process by which painters like Cézanne and Mondrian, and many others like them, sought to learn about the essential constituents of all forms. That they ended by emphasising those very stimuli which are the most effective for activating single cells in the brain reflects, I believe, the fact that the brain itself, through evolution, has built into its machinery those very elements which allow it to acquire knowledge about all forms. A painter contemplating what could be the constituents of all forms is essentially contemplating within the confines of the physiology of his visual brain. But this difference between the effortless activity of the brain in acquiring knowledge and the endeavours of artists brings us back to a statement that has already been referred to, namely that some artists paint whatever nature presents to their eyes, whereas others introduce a more intellectual effort into their paintings. Monet has frequently been given as an example of one 'who painted with his eye, but, Great God, what an eye'. I should therefore like to speculate here about the activity in Monet's brain, especially when he was preoccupied with his series paintings of Rouen Cathedral. I want to show that, even for one like him, the higher cerebral centres played a very critical role in his work, that his work was far from being an attempt to capture the fugitive moments, as some have claimed. The speculation has no direct evidence to support it but is based on such

21

onet's brain

f the world is a seemingly
aim, the artist by contrast
wledge that his brain has
higher mental activities
bination of a visual and
ers like Cézanne and
ought to learn about the
hey ended by emphasis-
st effective for activating
e, the fact that the brain
its machinery those very
vledge about all forms. A
constituents of all forms
onfines of the physiology
ween the effortless activ-
e and the endeavours of
nas already been referred
tever nature presents to
re intellectual effort into
n given as an example of
eat God, what an eye'. I
e about the activity in
s preoccupied with his
nt to show that, even for
played a very critical role
m being an attempt to
ave claimed. The specu-
it but is based on such

evidence about the physiology of the brain, and especially about the way that it constructs colours, that I have given in the last three chapters. In this sense it is no more, but also no less, interesting than common speculations about the state of mind of President Wilson or President Roosevelt when conducting political negotiations at Versailles and at Yalta, respectively, or that of Beethoven when writing his music. At any rate, it is fun to speculate about Monet's brain by viewing his paintings.

It is perhaps instructive to begin in a general way, by noting that Monet chose to paint the facade of Rouen Cathedral many times. Why he opted for the Cathedral (or for the Haystacks) in his series paintings, rather than for other views, must remain as much of a puzzle as why Cézanne opted for the Montagne Sainte-Victoire. That they both chose to represent the same scene in differing conditions reflects, I believe, their instinctive understanding that they must search for constancies, extract the essential properties and qualities of scenes and objects in ever changing conditions—and thus mimic unknowingly the function of the visual brain. But a casual glance at Monet's series of paintings of Rouen Cathedral is sufficient to raise a question in one's mind as to whether Monet was dyschromatopsic[1] through a partial lesion in his V4, that is to say limited in his ability to see colours, depicting colours more by the wavelength composition of the light reflected from every point in his field of view, rather than by being able to compare the wavelength composition of the light coming from one part with that coming from surrounding parts (see Chapter 18) and thus perceiving the colours as stable. The suggestion is insulting if not laughable, for nothing in the work of Monet suggests any gross visual abnormality. Monet painted the main facade of Rouen Cathedral at various times of day and in various weather conditions (Figure 21.1). Viewing them, one senses that either there was little effort made to compensate for the lighting or the time of day, or that he deliberately concentrated on every point rather than the entire scene and thus managed to paint the dominant wavelength reflected from every part. I should be very surprised if a dyschromatopsic patient, whose brain is unable to compensate for changes in the illumination conditions, would not similarly be heavily at the mercy of the wavelength composition of the light coming from every part, assuming him to have the painting skills of Monet. Roger Fry described the *Cathedral* series

thus: 'Monet cared only to reproduce on his canvas the actual visual sensation as far as that was possible ... he aimed almost exclusively at a scientific documentation of appearances' (my ellipsis),[2] Cézanne, who admired Monet, nevertheless thought that he painted with his eye. Both implied that Monet did not submit these 'visual sensations' to the rigours of the intellect, to the higher cerebral areas. In fact, we are told that Cézanne could not have painted a series like Monet in which variations in colour are emphasised, for the 'technical' reason that Cézanne painted slowly, 'with infinite hesitation ... thinking, comparing, restarting'. But to

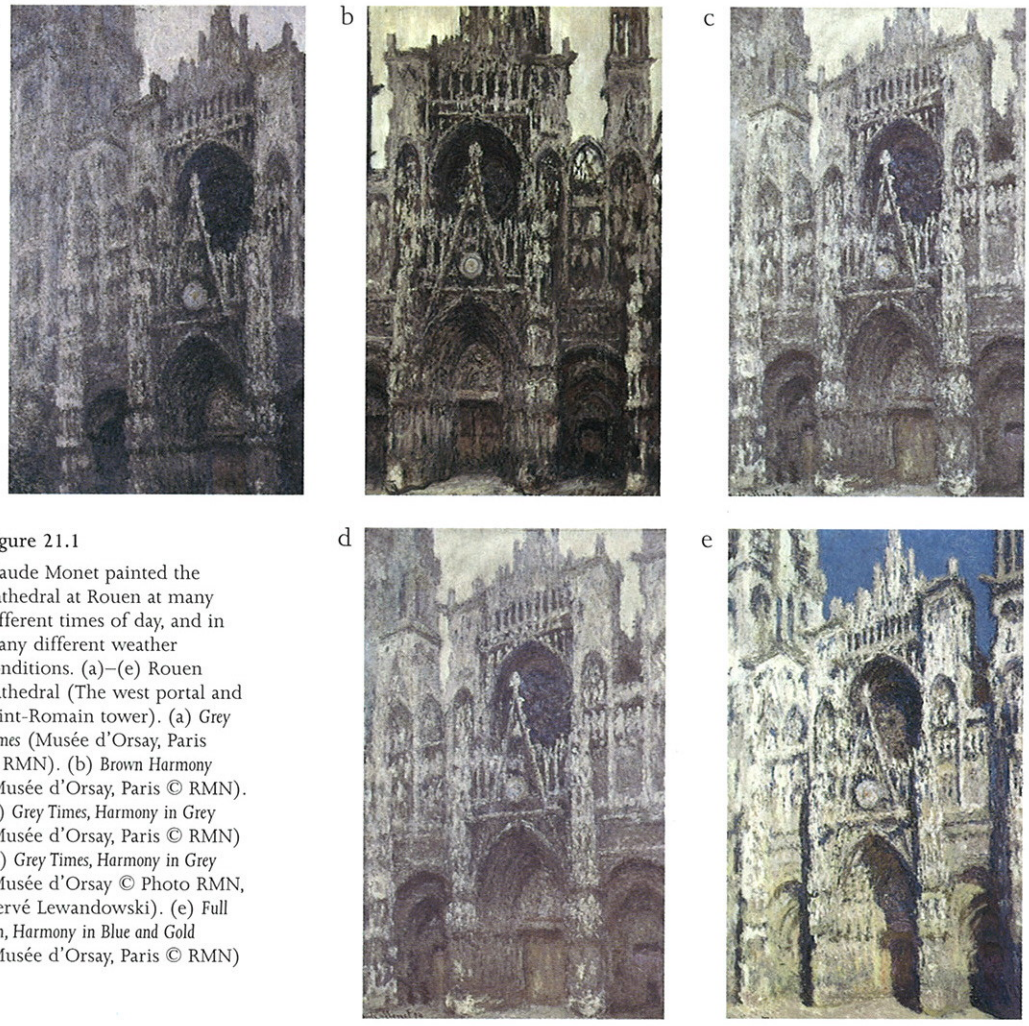


Figure 21.1

Claude Monet painted the Cathedral at Rouen at many different times of day, and in many different weather conditions. (a)–(e) Rouen Cathedral (The west portal and Saint-Romain tower). (a) *Grey Times* (Musée d'Orsay, Paris © RMN). (b) *Brown Harmony* (Musée d'Orsay, Paris © RMN). (c) *Grey Times, Harmony in Grey* (Musée d'Orsay, Paris © RMN) (d) *Grey Times, Harmony in Grey* (Musée d'Orsay © Photo RMN, Hervé Lewandowski). (e) *Full Sun, Harmony in Blue and Gold* (Musée d'Orsay, Paris © RMN)

e on his canvas the actual
ssible … he aimed almost
ı of appearances' (my ellip-
evertheless thought that he
ıat Monet did not submit
f the intellect, to the higher
ıt Cézanne could not have
ı variations in colour are
ıat Cézanne painted slowly,
mparing, restarting'. But to

capture the changes in 'colour harmonies' one has to fix things rapidly, 'before the capriciousness of the sun has destroyed it'.[3] There is, however, no evidence to suggest that Monet painted quickly in order to capture fleeting visual sensations. On the contrary, he often re-worked his paintings of the Cathedral, sometimes in his studio after he had captured the main effects *in situ*. Monet's *Cathedral* series provides, therefore, fertile ground to see whether a distinction between a 'retinal' painting and a cerebral painting is at all sound neurologically.

It is a very great pity that the thirty paintings of Rouen Cathedral, of which twenty-eight are of much the same view and were executed in various weather conditions and at various times of the day, are not usually exhibited together, since no single museum owns the whole series, the largest number, six, being at the Musée d'Orsay in Paris. Georges Clemenceau, a great admirer of Monet and one who, to his immense credit and to the credit of the country that he represented, found time to leave Cabinet meetings to exhort an exhausted Monet to continue his work, wanted the paintings to be exhibited together; he lamented vainly that 'there has not been a millionaire … to say: "I buy the lot", as he would have done with a bundle of shares'.[4] It would have been good if someone had done so and exhibited them together. For it is in fact only when one views them as a series that one begins to realise the extent to which Monet, deliberately, failed to compensate for changes in lighting conditions. Indeed, he exaggerated the dominant wavelength to such an extent that one initially suspects a dyschromatopsia. Paintings apparently made in the early afternoon on a cloudy day (Musée d'Orsay) differ significantly in colour from those made at the same time but on a sunny day (National Gallery, Washington). Or, one painted in the late afternoon (Narodni Muzei, Belgrade) differs substantially from another one executed at the same time of day but perhaps in different weather conditions (Pushkin Museum, Moscow) (see Figure 21.1). And so the list of paintings, which should not differ so significantly in colour to a normal observer, goes on. Judging by the sky, the Moscow *Cathedral* must have been painted on a sunny afternoon while the Belgrade one must have been done on a cloudy afternoon, although one suspects a break in the cloud to account for the intense violet-pink that is the hallmark of the latter. This, one might say, is the work of a brain that is unable to

'discount the illuminant'. It is not surprising that critics thought that Monet painted with his eye.

There is little doubt that Monet was throughout concerned about the weather and tried to capture the effects produced by different lighting conditions. His letters during this period must have been extremely tedious to read and could have been written by a weather forecaster of the more boring variety; almost without exception they refer to the weather, to such an extent that they have almost become a record of the weather conditions during the time he painted in Rouen. But although some of the paintings may have been finished outside, many were in fact executed inside, in rooms that he had hired with a view of the Cathedral. More significantly, many were re-worked later 'from memory', obviously not always with a satisfactory outcome because of statements such as 'I have destroyed all my sunny canvases'. This suggests that, far from painting 'fleeting' impressions, Monet imposed a good deal of knowledge, based on his previous visual experience, on these paintings. A remark in a letter confirms this: 'The weather has stayed the same, but alas, it is now myself and my nerves that keep changing with each break in my work'.[5]

It is doubtful whether a dyschromatopsic or achromatopsic patient would be able to re-work the paintings from visual memory, as Monet evidently did. Achromatopsic patients commonly do not even have any memory for colours, a loss that disturbs some of them. They also commonly cannot dream in colour either, as Monet seems to have done.[6] Seemingly the individual areas provide a great deal more than the mere 'seeing' of an attribute. They also contribute to the understanding of that attribute, and even to a memory for it.

Let us use such knowledge of the brain as we have acquired to surmise what might have been happening in Monet's brain when painting the *Cathedral* series. In this analysis, I concentrate on colour alone, since it is this that varies most obviously in the Rouen Cathedral series. We assume that the colour constancy mechanisms were operating normally in him and that, when he viewed the Cathedral, his brain was able to discount automatically the lighting conditions in which the Cathedral was viewed. Monet's brain, and more specifically the specialised colour system within it, would thus have been activated when he viewed Rouen

prising that critics thought

vas throughout concerned
re the effects produced by
rs during this period must
ıd could have been written
re boring variety; almost
ther, to such an extent that
of the weather conditions
But although some of the
de, many were in fact exe-
hired with a view of the
ere re-worked later 'from
h a satisfactory outcome
estroyed all my sunny can-
ting 'fleeting' impressions,
dge, based on his previous
gs. A remark in a letter
he same, but alas, it is now
ing with each break in my

natopsic or achromatopsic
he paintings from visual
romatopsic patients com-
for colours, a loss that dis-
ly cannot dream in colour
Seemingly the individual
the mere 'seeing' of an
ne understanding of that

ain as we have acquired to
ing in Monet's brain when
nalysis, I concentrate on
es most obviously in the
hat the colour constancy
in him and that, when he
e to discount automatically
e Cathedral was viewed.
e specialised colour system
ed when he viewed Rouen

Cathedral, the activation almost certainly including V1 and V4; the former would have been involved in detecting the wavelength composition of the light coming from every point in his field of view and the latter in a comparison of the wavelength composition coming from one part and from surrounding parts, thus leading to a constancy for colours. We can also assume that the zone lying just in front of V4 would have been activated, just as it is in normals when they view a naturally coloured scene. Finally, both his hippocampus and his inferior frontal convolution would have been active. All this can be surmised from what happens in the brain of a normal subject when he views a coloured scene.

The inferior frontal convolution is especially interesting. It is a zone that becomes active when humans view objects that are dressed in their natural colours. By contrast, when they view the same objects dressed in unnatural colours, it is a different part of the frontal cortex—located in the middle frontal convolution—that becomes active. Yet sophisticated analyses show that these two subdivisions of the frontal cortex are in communication with each other, as if one informs the other of the activity within it. I therefore hypothesise that, when Monet undertook his series paintings of Rouen Cathedral, he was using both subdivisions of the frontal lobe. He was, in fact, using the knowledge in his brain to deliberately paint something that departed from what he was actually seeing. His paintings may indeed be considered to be the first Fauvist paintings. This does not amount to painting 'fleeting' impressions at all, as many have supposed.

Let us recall that Monet had lamented to Clemenceau that he wished that he could be born blind and that vision be restored to him suddenly, so that he could paint forms without the corrupting influence of past experiences. Here, then, was a man trying to rid himself of any influence that might interfere with his sensations, as he saw it. How could one do this in colour? Quite simply by ceasing to be a contextual painter, that is to say, by painting the colour of every small part almost in isolation, without regard to the surround. But to do so one must of course ignore the surround, a difficult task since it is built into the visual perceptive system. And hence the intellect must be brought to bear to reinterpret the colour of every part as if the colour constancy mechanisms had not been operating. It is for this very reason that Monet could complete, I believe, his paintings in his studio, away

from the actual condition prevailing at a given time of day. What was needed to complete these paintings was the use of memory and the intellect, to override as far as possible the constancy machinery.

My analysis is conjectural and may turn out to be partially wrong. I doubt, given the facts that we know, that it will be entirely wrong. But that is not the point of this excursion. Its importance lies in suggesting that Monet was not painting fleeting impressions, nor was he painting with his eye (as opposed to his brain), nor was he painting quickly. He was, instead, using his cerebral powers to maximum effect, no less than Cézanne and others who are considered to be cerebral rather than retinal painters. But he was probably using, at least in part, different cerebral pathways from those who painted similar scenes in natural colours. This, once again, emphasises a cardinal point—that different modes of painting make use of different cerebral systems. But Monet's story, and the efforts behind his paintings, also emphasises one of the main themes of this book—that one of the functions of painting is to acquire knowledge about this world. Monet sought in his paintings to acquire knowledge about a world that was uncorrupted by his experience of it, as his vain plea to Clemenceau makes clear. And to do so he had to use an extensive part of his cerebral visual apparatus. Perhaps it would be better to say that 'Monet painted with his brain but, Great God, what a brain'.

---

1. Pissaro, J. (1990). *Monet's Cathedral. Rouen 1892–1894*, London, Pavilion Books shows the whole collection of Monet's paintings of the Cathedral.
2. Fry, R. (1932). *Characteristics of French Art*, Chatto and Windus, London.
3. Brion-Guerry, L. (1966). *Cézanne et l'expression de l'espace*, Albin Michel, Paris.
4. Pissaro (1990), loc. cit.
5. Ibid.
6. Ibid.