Dissertation

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The neurological basis of visual perception

What can this tell us about the creative process in the visual arts and other aspects of the human psyche?

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Synopsis

The last 50 years has seen a veritable explosion in knowledge about the activity of the human brain, especially since the development of functional magnetic resonance imaging (fMRI) has made it possible to study the visual activation of the brain in conscious living subjects. This dissertation looks at the current state of knowledge of the processes of visual perception in the human brain and the neurological basis of artistic creativity using examples of visual art from prehistory to the present day. Since all human activity ultimately arises from the brain this rapidly expanding body of knowledge has profound implications for philosophical, moral and social issues, which are discussed.

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Introduction

Figure 1: Author, *Outside*. 2010. Pyrography and watercolour on board. 12”x12”

It was a calm night in winter and a bright moon lit up the frost on the trees and grass below. I surveyed the scene from my vantage point above a broad, dark conifer and could just make out a figure sitting motionless on a concrete step at the edge of the circular lawn. I felt calm and serene cocooned in a blanket of comforting silence. I was content to wait and see what would happen to this motionless person. Would they get up and walk away? I knew it would not have bothered me if they disappeared as I felt safe where I was, quite separate. Neither of us moved for a very long time. Then suddenly I was sitting down on the step wearing my old jacket, blue with cold and shivering violently, “joined up” with “the other one” and terrified, on the edge of emptiness. That was the start of it. The moment I knew I needed professional help and the start of a chain of events that led to me to become an artist.

Although “abstraction” and “negative spaces” were not terms I had heard of when I was a child, I remembered spending long hours fascinated by the search for interesting shapes thrown up within the environment around me. Visual puzzles were everywhere but it was not until I studied art and developed an interest in the new neuroscience of art that I realized that these are fundamental aspects of visual perception that the brain uses for lightning quick processing to make sense of the world. A favourite game of looking for faces in everyday objects (visual pareidolia, applying an illusory significance to a visual illusion) is now regarded as one of the early acquisitions of the brains of our ancestors and a central feature of human intelligence (Harth in Goguen, 1999: 106). One such example is shown below (figure 2) where a ghost like face is seen in a leaf eaten by insects.

Figure 2: Seeing a face in a leaf- an example of recognition of an external image known as visual pareidolia. Google images @ Humourcafe.blogspot.com

When I first began my medical career, knowledge of brain function was limited largely to information gained in cases of specific brain injury linked to anatomical findings at postmortem, compared with “normal” brains. It was thought that visual information from the retina was “seen” in a specialized area of the occipital cortex at the back of the brain, identified as “V1”, as a largely passive process and then interpreted or understood by the surrounding association cortex. Although we are still a long way from understanding the vast complexity of the human brain, stunning recent advances in neuroscience, especially functional magnetic resonance imaging (fMRI), which allows dynamic imaging of the brain in the conscious individual, have revolutionized our knowledge of the visual brain.

We now know that about one quarter of the brain is devoted to the visual system and that there are multiple areas of the cerebral cortex each with its own associated specialist visual function, which can act autonomously in processing and perception. The brain is seen as the active generator of the visual image using rapid parallel processing of limited information from the eye. In order to achieve such a feat, in a constantly changing environment, the brain is organized to abstract only features that are essential to make sense of what is in the field of vision, using inherited concepts, such as colour perception and acquired generalizations, or concepts which are modified by experience, such as recognition of objects or specific faces (Zeki, 1999: 1-7).

Abstraction is therefore key to how the brain acquires knowledge about our environment through vision. It is fascinating and no coincidence that visual artists have been using abstraction as a fundamental tool in creating their work and, through experimentation, have developed techniques which reflect and exploit the organization of the visual brain, without having any knowledge of brain function. Although in 1871, Hermann Helmholtz, the German physician who developed the ophthalmoscope, predicted that the study of artistic practice and works of art would ‘throw great light’ on the process of vision (Hyman, 2010), it was Semir Zeki (1940) a neurobiologist with a specialist interest in visual perception, who was first to acknowledge the artist as the earliest neuroscientist (Zeki, 1999:10). Zeki believes that the more we understand about how our brains acquire knowledge, for example through vision, the better we will understand brain function and what it produces, including art and creativity. David Hubel (1926), the co-winner of the Nobel Prize in Physiology and Medicine in 1981 for mapping the visual cortex, is of the same view when he states that:

> In the future, visual neurobiology will enhance art in much the same way as a knowledge of bones and muscles has for centuries enhanced the ability of artists to portray the human body (Hubel, 2002, foreword to Livingstone, 2002: 8).

A number of international academic centres are now collaborating with contemporary artists, exploring the pathways of visual perception, to further define brain function in relation to the creative process. These include University College London and University of Leicester, UK, Université Paris Descartes, France, University of Geneva, Switzerland, University of Oslo, Norway and the Universities of Nevada, California (San Diego and Santa Barbara), Harvard and Stanford in the USA.

I began the research that eventually led to this dissertation in the hope that I might gain some understanding of the process of mental disintegration I had experienced. Since my subsequent recovery progressed side by side with my training as an artist, I was fascinated to study how my observations and experiences that took place during this period might influence my creative output in the studio. I wanted to explore current opinion about the creative process and mental illness, especially amongst visual artists. I then expanded my enquiry from the more scientific literature of evolutionary biology, psychiatry and neurology through psychological specialties, archaeology, anthropology, philosophy, art history and historical and contemporary artists. I chose to concentrate on the areas of this research that are most closely linked to personal feelings and thoughts about my own artistic practice, which are inevitably influenced by my background in clinical medicine and interest in brain development and function.

The place of art in human culture has exercised the minds of academics for millennia, for example the Greek philosopher Plato (428-348 BC) who included a critique of art in Book X of The Republic. (Hamilton (ed), 2005) and inevitably the recent, rapid advances in the neuroscience of sensory perception are challenging established opinion both in science and the humanities. I find evidence of an increase in collaboration, which seeks to cross the artificial disciplinary boundaries inherent in our academic system; for example the three combined volumes of papers entitled *Art and the Brain*, published by *The Journal of Consciousness Studies*, which bring together eminent academics from the humanities and science who share an interest in art, creativity and sensory perception (Goguen, 1999, 2000 & 2004). The earlier volumes reflect many of the authors' predominantly critical views of the neuroscientists, even attaching the derogatory term of 'reductionism' to their contention that understanding the science of visual perception will add to our understanding of art and the aesthetic experience. They regard 'perception as the activity of the whole person', (Myin in Goguen (Ed), 2000: 52) maintaining that the artist and the process of creativity have largely been excluded from the neuroscientific response. In my opinion this is unwarranted criticism since I do not detect any evidence that neuroscientists such as Semir Zeki and Vilayanur Subramanian Ramachandran (b.1951) are trying to diminish the importance or complexity of the artistic process, merely trying to enhance the knowledge base in the field of visual perception and to stimulate healthy academic debate.

In this dissertation I intend to survey key aspects of the recent discoveries in visual perception within the human brain and how these relate to specific examples of historical and contemporary art. My sources are cross-disciplinary, from science (including neuroscience, neurophysiology, neurological medicine, neuropsychology, psychiatry and evolutionary biology), philosophy, art history, literature, historical and contemporary artistic practice, self reflection and personal experience. I have found the publications of a few authors of particular value and have therefore referenced them more often than others. Within the field of neuroscience, I feel I have a particular affinity with the work of Semir Zeki, because of the clarity of his writing and the breadth of his knowledge of many art forms. Although I have not met him or heard him lecture, his writing conveys an immense enthusiasm for his specialism in neuroscience and visual perception and how this can illuminate the creative process that is an integral part of human behaviour. I have also found the work of Patrick Cavanagh, from the field of psychology of visual sciences, particularly helpful and was fortunate to hear him lecture on the subject of the artist as neuroscientist. The other two writers I would highlight are Siri Hustvedt (1955), an American essayist and writer and Darian Leader (1965) a contemporary psychoanalyst with an interest in art. Hustvedt's 'verbal wanderings on art' and the human experience are thought provoking and written with a fluidity and clarity of style that I found much easier to connect with than many art theorists. This may be because she talks in depth about her personal experience of viewing the painting not just on one occasion, but over repeated viewings over her lifetime. Darian Leader has written extensively on psychoanalytical theory, philosophy and the relationship between creativity and mental illness. I found his approach and style gave me a basic understanding of some of the more difficult aspects of philosophy and psychoanalysis which other authors could not. Inevitably I have had to be selective, given the breadth of this subject, and I have chosen to concentrate on two key areas, abstraction and ambiguity, where I see a clear link between brain function and the creation of visual imagery, through my own artistic practice.

The first chapter establishes the concept of the artist as the first neuroscientist. There follows a summary of some key aspects of the anatomy and function of the visual system, which underpin the discussion of the rapidly developing field of neuroaesthetics. The main investigative techniques that are being used to study the visual system are briefly described. Chapter two focuses on the process of abstraction that I consider to be a fundamental function of the visual brain. I discuss this from a neurological point of view and highlight parallels with the artistic practice of the Dutch artist Piet Mondrian (1872-1944) who sought to uncover the fundamentals of visual perception both in a direct and a spiritual sense through the critical analysis of his creative output as a painter. Chapter three is an investigation of the link between various forms and levels of ambiguity in visual imagery and the generation of an emotional response in the viewer and how this impacts on our memory. The final chapter, chapter four, starts by considering the philosophical concepts of “the unfinished” and “the ideal” in the context of visual art and their place within the creative process. The wealth of knowledge now being gained about functional processes in the visual cortex is probably applicable to cortical activity elsewhere in the brain, and therefore all cognition. Inevitably, our analysis and theories of philosophy, mental illness and psychoanalysis since humans began creating a written record have taken place without the benefit of knowledge of the workings of the brain. Since the brain is the ultimate source of these deliberations and the organ with which we try to understand the world around us, the rapid advances in neuroscience should give new and exciting insights into human behaviour and some of these will be discussed in the concluding part of this final chapter.

Chapter One

Artists as Neuroscientists

Figure 3: Henri Matisse, 1945, self portrait lithograph, Escholier, 1960, *Matisse from the Life*: 175.

One of the artistic qualities that I admire most is the skill of an artist who can capture the essence of a form in a minimal number of lines. The French artist Henri Matisse (1869-1954) had this ability and was able to produce an instantly recognisable self portrait in this way (figure 3). I know from experience that this is not an easy skill to master and that it requires keen observation to recognise the essential lines that define the specific face or form. Although I admired the skills of the prehistoric artists who produced the glorious coloured drawings of animals discovered in the caves of Chauvet in France in the nineties, (figure 5) I did not really appreciate just how strong a link exists between them and someone such as Matisse or even myself. Only now, having engaged in research on visual perception, have I some understanding of the basis on which the brain understands line and the form it defines, and the profound connection that exists between the artists of today and those of 40000 years ago.

Figure 4: Henri Matisse, 1932, etching. http://www.henri-matisse.net/drawings/draw.jpg.

Just as Matisse's two dimensional etching on paper (figure 4) is instantly recognisable as a female form, we have no problem in seeing the cave painting as a group of lions moving through a three dimensional landscape.

Figure 5: Lions Chauvet caves, 35,000 yrs BC, discovered 1994, Google images

It is clear that the Chauvet painters already understood the importance of line, shape, colour, light and shade to suggest form, and how depth perception and overlay of images convey movement in a three dimensional space.
These are some of the fundamental elements we use as artists today and I find it fascinating that neuroscientific research has revealed that each of these aspects of our visual landscape is separately coded within the brain. (Cavanagh, 2012); (Zeki, 2002: 918) This is one of the reasons Patrick Cavanagh, a research psychologist, recently expressed his agreement with neurobiologist Semir Zeki in his view that visual artists were the first neuroscientists, since they have been experimenting for hundreds of years on how to represent 3-dimensional forms in 2-dimensions, so that they can be interpreted by the visual systems of the observers of their art. (Cavanagh, 2005)

Although the cave artists used much more than just the outline of the lions in their painting, a simple outline drawing would still have been interpreted as running lions. In a presentation at the World Science Festival recently, Patrick Cavanagh presents convincing evidence that this capacity of our brains to understand that lines separate a form from the background is innate and not acquired. This characteristic was not only present in our early ancestors but crosses cultural divides and can be demonstrated in human infants and in other species such as monkeys and insects. It is also a characteristic of single cell neurons such as those that respond to an outline of a familiar face. Even blind people have the same appreciation of a three dimensional form as a sighted person, when they trace a raised outline of a drawing, using touch

(Cavanagh, 2010). Cavanagh believes that the shortcuts that artists have developed which allow them to bypass the rules of physics regarding directional light, shadows, reflections and contours, but still present a plausible image to the viewer, indicate that our visual brain employs a simplified internal physics. This is not only used to appreciate paintings and drawings, but is essential for our quick and efficient perception of the real world.

Figure 6: *Shadows*, pen on paper, author's drawing 2013

My own drawing of a receding figure in strong directional light (figure 6) illustrates that the shape of the shadow and its direction does not matter too much to the interpretation. From examples in renaissance art, such as The Birth of the Virgin by Fra Carnevale, 1467, where shadows are not correctly orientated according to the light source, Cavanagh concludes that provided the shadow is darker than the surroundings and closely related to the object casting it and without its own outline it will read as a plausible shadow, irrespective of the direction of the light. He also notes that artists have learnt that they can take similar liberties when representing reflections and in paintings of water and glass, where even quite gross deviations from the laws of refraction go unnoticed. (Cavanagh, 2005) He ends his discussion thus:

> ..thousands of years of trial and error have revealed effective techniques that bend the laws of physics without penalty. We can look at their work to find a naive physics that uncovers deep and ancient insights into the workings of our brain. Discrepancies between the real world and the world depicted by artists reveal as much about the brain within us as the artist reveals about the world around us. (Cavanagh, 2005, 306: 307)

Investigative techniques used in neuroscientific research

In the last sixty years specialist tools have become available to study how the brain interprets sensory information in the conscious individual. These include: microelectrodes and their associated amplifiers and electronic apparatus, which can pick up activity of single nerve cells in the brain; advanced neuro-anatomical techniques to delineate how cells are interconnected (Hubel in Livingstone, 2002: 8); sophisticated surface electro encephalography known as SST (Steady State Topography) shown in figure 7 (Silberstein, 1990); and functional magnetic resonance imaging or fMRI, (see figures 8 & 10) (Belliveau, 1991) and (Calvert, 2012).

Figure 7: Subject wearing head device used in Steady State Topography to record brain activity, Thinkbox, 2010.

Figure 8: fMRI Scanner showing the table the subject lies on when entering the magnetic coil that surrounds the head, which is stabilized within an open cage. Calvert, 2012.

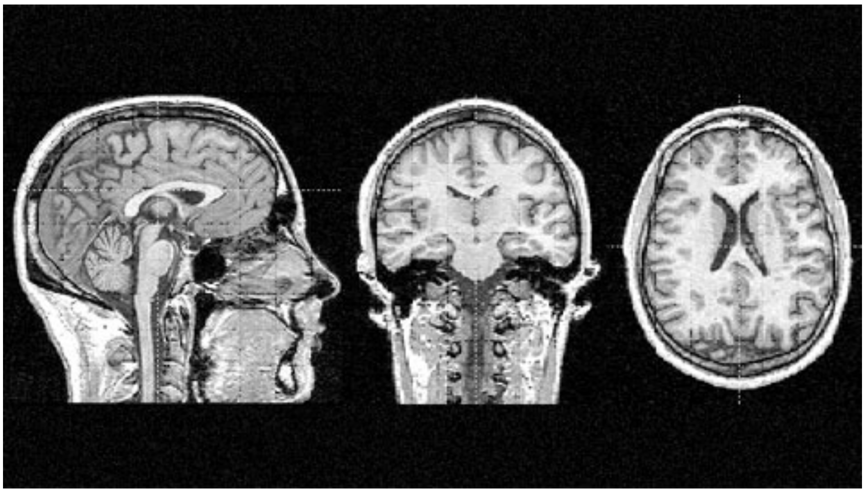

Figure 9: MRI scan of human brain. Calvert, 2012.

Cross sectional scans of the human brain using magnetic resonance imaging (figure 9:MRI) provide detailed images of the anatomy but tell us nothing about function. Physiologists in 1890 observed that Increased neuronal activity is associated with increased blood flow. One hundred years later this observation was used to combine the detailed anatomical images of the brain from MRI with functional changes on activation, in the fMRI. These areas of activation show up as the red and yellow areas in figure 10 (Calvert, 2012).

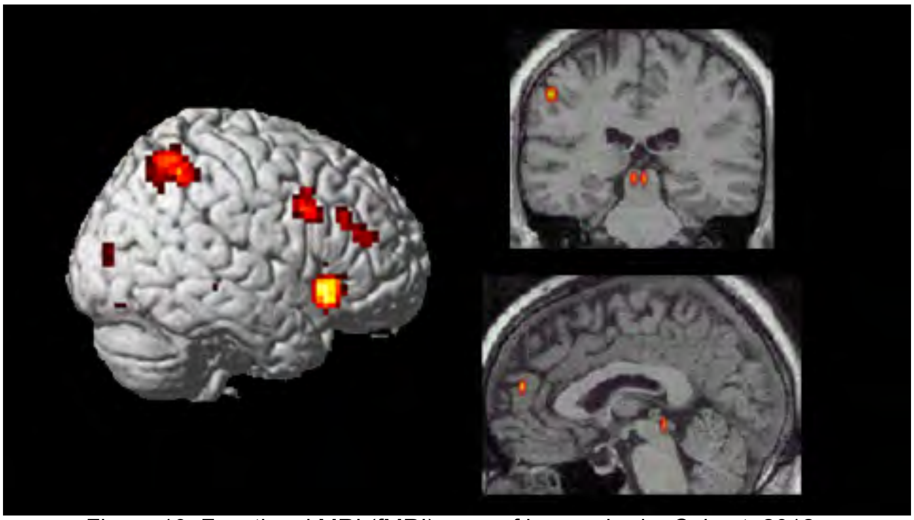

Figure 10: Functional MRI (fMRI) scan of human brain. Calvert, 2012.

The Visual Pathway

In the early part of the twentieth century it was thought that the eye functioned much like a camera in that light sensitive cells in the retina at the back of the eye created a visual map of the field of view which was transmitted via the optic pathways to the primary visual cortex, known as V1, in the occipital lobe shown as a yellow area at the back of the brain in figure 11.

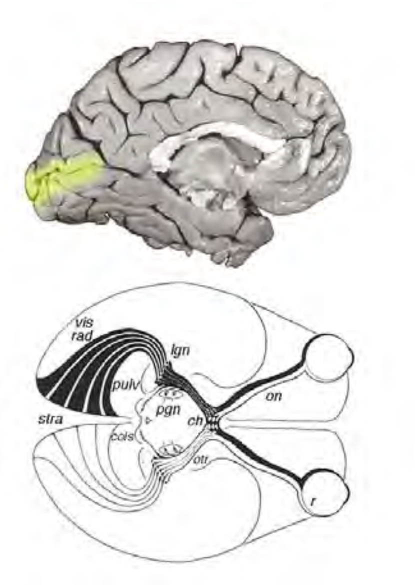

Figure 11: A diagrammatic representation of the optic pathway between the eye and the brain (bottom). A chain of nerve cells transmit signals from the retina to the visual cortex via the primary visual cortex (area V1), shown in yellow on the medial side of the left hemisphere (top). Zeki, 1999:15.

We now know that the retina generates only raw, simple visual stimulus patterns which are processed through a number of staging posts along the optic pathway and that there are many different kinds of signals that pass through V1, for example for colour, luminance, motion, form and depth. Neurons sensitive to each attribute are grouped together, forming concentrated islands of high metabolic activity specific for their attribute. (Harth in Goguen, 1999: 98) These islands of cells in V1 (yellow area figures 11 & 12) send the signals onwards to specialized visual areas directly and indirectly through V2 (green area in figure 12, an intermediary area surrounding V1), much like a sorting office (Zeki, 1999: 60).

Figure 12 shows some of the specialized areas of the cortex that are devoted to process selective visual information.

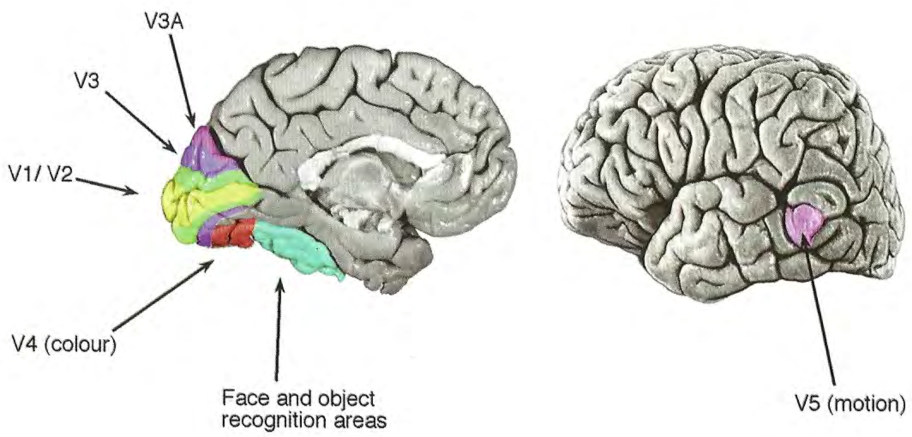

Figure 12: A diagram of the human brain showing the main visual areas of the cerebral cortex. The image on the left is a cross section along the midline, with the back of the brain on the left and shows areas V1 to V4 in the occipital lobe and face and object recognition areas in the lower medial area. The diagram on the right shows the outer surface of the left hemisphere of a brain, with the back of the brain on the right of image. V5 the motion centre is indicated in purple, near the front of the outer part of the occipital lobe. Zeki, 1999: 16.

Functional specialization and the receptive field

Functional specialization is a fundamental characteristic of the neuronal cells in the visual pathway and the cerebral cortex. The significance of this is that each specialized element of the visual pathway from retinal cell to cortex delivers only the essential visual information required to interpret that particular attribute and to reach consciousness. When considering functional specialization at the level of single cells, each cell in the visual system has a receptive field. This can be defined as the region in the visual field to which the nerve cell is sensitive, in other words a part of visual space. When the receptive field is visually stimulated the cell will react generating an electrical discharge, provided the stimulus is specific to the cell type. For example a cell may respond only to stimuli that move in one particular direction, or to a particular colour (Harth in Goguen, 1999: 98).

The diagram below in figure 13 illustrates functional selectivity in a cortical cell for movement in one direction.

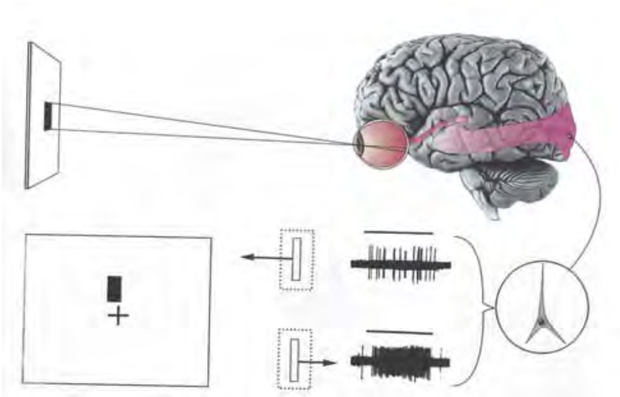

Figure 13: Directional Selectivity. Response of a cell in the visual cortex to a bar moving from left to right, stimulating its receptive field (lower left). It is unresponsive to movement in opposite direction. Zeki, 1999: 62.

The diagram in figure 14 shows the activation of a single cortical cell that is specifically sensitive to the colour red. No reaction occurs with other colours in its receptive field.

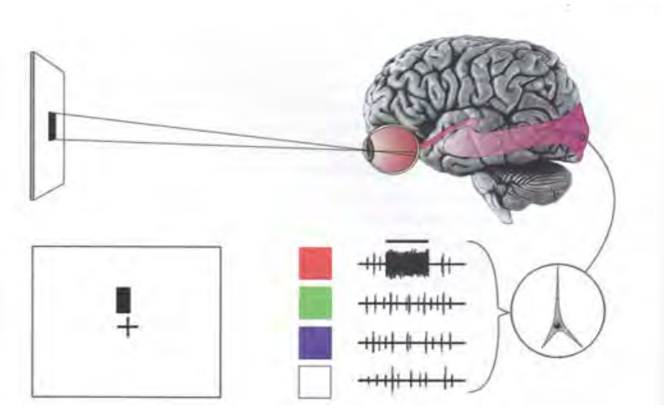

Figure 14: Selectivity for red light. A cell from visual cortex increases its electrical discharge in response to red light (long wavelength) but not to other colours (medium and short wavelength) or white light. Zeki, 1999: 61.

The experiment using fMRI shown in figure 15 demonstrates what happens when a human subject looks at rectangular coloured shapes on a screen. V1 and the specialist colour centre V4 light up in activation.

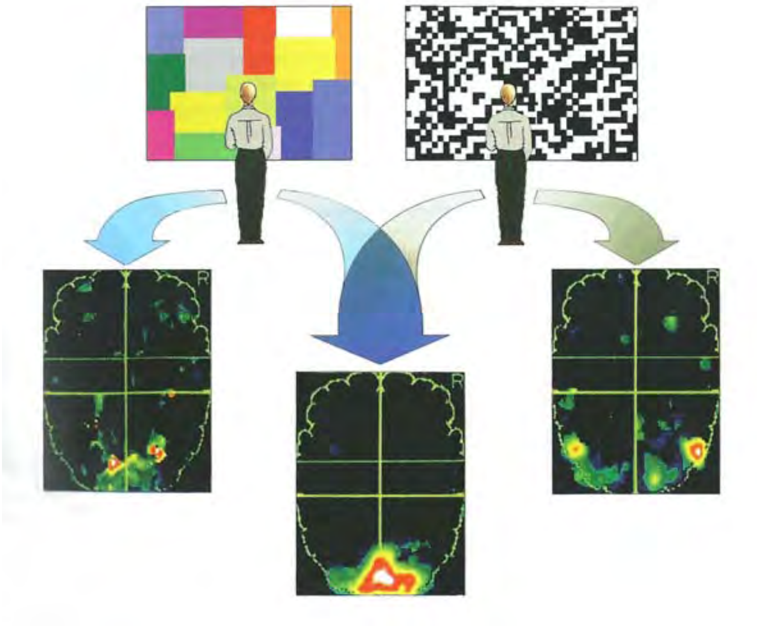

Figure 15: Experiment to demonstrate Functional Specialisation in the human brain, using fMRI. Viewing a coloured screen stimulates V1 and the V4; viewing a screen of moving black and white squares stimulates V1 and V5. Zeki, 1999: p64.

The stable, inherited and unconscious process that leads to colour perception is now well understood. The brain is only interested in the how a surface reflects light of different wavelengths and assigns a colour to that surface by making a comparison between the wavelength composition of the reflected light from the surface and that reflected by the surrounding surfaces. We know that this starts from the retina when information on the relative ratio of light of short, medium and long wavelength is sent from the photosensitive cells via a number of processing “substations”, through V1 which sends it on to V4 where conscious recognition of colour takes place. This is how our brains can assign a consistent colour to a surface or object despite the wide variations in the wavelength compositions of light reflected from it which occur with changes in ambient light or going from daylight to artificial lights, the phenomenon of colour constancy. (Zeki, 2009: 73) This ratio-taking property is assigned to the colour centre of the visual cortex, V4. Studies using fMRI have shown that when we become consciously aware of the colour of a surface only V1, V2 and V4 are active with no involvement from higher cortical regions. The colour of a surface is therefore not open to our interpretation since there can be no ambiguity about the physical properties of surfaces in terms of their reflectance of light. Had the viewed image been of objects rather than abstract shapes, several other cortical areas (inferior temporal cortex, hippocampus and frontal cortex) would have activated since they are involved in the process of investing objects with colour and monitoring if this is appropriate (Zeki, 1999: 203). When the subject views small moving, black and white squares activation of V1 occurs as expected, but also V5 where the motion sensitive cells are localized. Many other brain imaging studies have been conducted in living subjects which have mapped the cortical areas of functional specialization, not just for visual perception.

Another source of evidence for functional specialization has come from the study of individuals with distinct areas of brain damage. For example, a person with damage to the face recognition area of the cortex (pale blue in figure 12) cannot recognize familiar faces, a condition called prosopagnosia. They can, however, see individual features and even recognize the expression on that face, but cannot put the information together to identify the face as familiar. We can deduce from this that this area known as the fusiform gyrus is uniquely required to enable familiar face recognition but that the remaining undamaged part of this visual pathway can recognize a face in general. Oliver Sacks, the well-known neurologist and lifelong sufferer of prosopagnosia, has written a vivid account of this condition (Sacks, 2010). Similarly when V4 the colour recognition area is destroyed, the subject can only see in grey tones and has no concept or understanding of colour.

One further piece of evidence to support functional specialization has come from an observation made by George Riddoch, a neurologist, who documented how soldiers blinded by gun shot wounds during the great war were conscious of seeing motion in their blind fields of vision, but nothing else. At the time this did not fit in with the accepted view of visual organization, that complete destruction of V1 would lead to total blindness. In 1998 fMRI studies on a blind patient who was presented with a fast moving stimulus, activated V5, the motion centre, (yellow spot left column of images in figure 16) although slow movement did not. In neither case was any activation detected in V1 (see figure 16) but the patient could detect and understand rapid motion. (Zeki, 1999: 78,79)

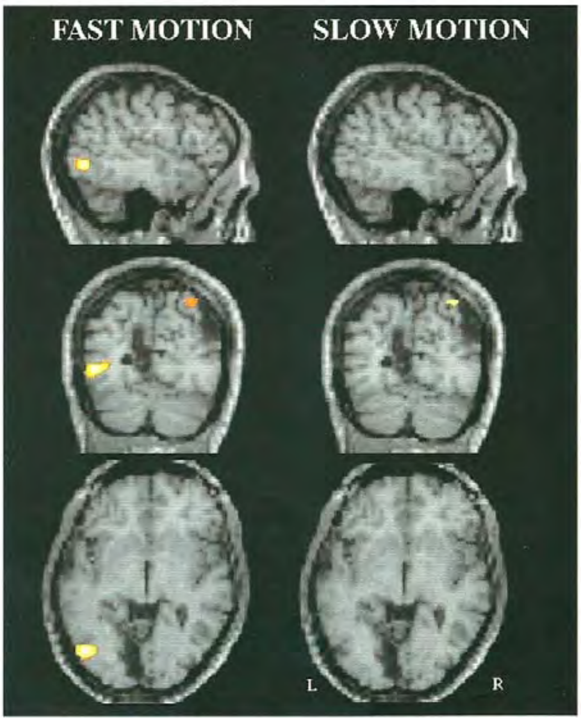

Figure 16: fMRI of subject blinded by damage to V1, showing activation of V5 by fast motion (left) but not by slow motion (right). Zeki, 1999: 79.

Zeki comments:

> This adds evidence that these areas are autonomous and not dependant upon a central area, and that activity in them can lead to both seeing and understanding. I do not of course mean to imply that cognitive factors do not come into play in interpreting what is seen, in what is known as top-down effect. Seeing is perceiving is understanding. (Zeki, 1999: 79,80)

It would seem that visual perception in the brain is made up of multiple discrete modalities that rapidly process information in parallel, although it does not necessarily follow that the different attributes are perceived separately and it is assumed that some sort of integration occurs in the brain. This however takes time, probably at least one second, and signals travel along nerve cells very fast. Research has shown that the earliest visual signals reach the cortex in 35 milliseconds and that colour is perceived before form and some 60-80 milliseconds before motion (Zeki, 1999: 65-67).

From the present evidence, neuroscientists agree that the different processing systems of visual perception have a degree of autonomy as well as interacting with each other. The pathological evidence and the apparent lack of a single area for the integration of the disparate aspects of the image support this. Neuroscientists regard the discovery of functional specialization as fundamental to the present view that vision is an active process. The brain is actively generating the visual image using a physiological search for constants and essentials that makes the brain independent of continual change and then processing them according to highly complex internal programs. (Zeki, 1999: 67-68)

This active search for constants and essentials could be a definition of the process of abstraction, an integral part of artistic practice and aesthetic appreciation of visual art and a subject for discussion in the next chapter.

Chapter Two

Abstraction

The term abstraction is derived from the Latin verb *abstrahere,* (*abs*-, from, *trahere*, to draw) i.e. to draw from or to take away (Baker, Ed, 1932: 5). It is surprising, but logical, to see the use of the word draw in this definition and to represent the manual action of 'drawing' an image. *Draw* can be traced back to the Middle English *drauen* from the Old English *dragan* (Collins English Dictionary, 2003). Before I became an artist, I was familiar with the term abstract associated with art in relation to images that do not contain any recognizable form. Now, however, I regard the process of abstraction as fundamental to drawing and to all artistic practice. In my view all art has to be an abstraction since an artist can only ever produce a partial representation of their subject.

It is not surprising that the search for a 'true reality' has exercised the minds of many artists and has led them to explore philosophy, spiritualism and science. One such artist who sought to do this through abstraction was Piet Mondrian who with the poet and artist Theo Van Doesburg founded the De Stijl (The Style) movement in the Netherlands in 1917. They termed their approach to their studio work *Neo-Plasticism* and for Mondrian the lifelong quest for reality within his art became a spiritual journey. The question of what constitutes reality, not just in the visual sense, was one that fascinated Mondrian and he sought to find the answer through his art. Although he wrote extensively on many aspects of his practice, the most interesting text in my view is *Toward* *the True Vision of Reality*, his only autobiographical essay which he wrote in 1941 three years before his death and which was published in connection with his first exhibition in the United States in 1942 (Mondrian, 1941, in Holtzman, (Ed), 1987). Taking into account his writing and art it is not difficult to appreciate where aspects of Mondrian's artistic practice could be linked with the neuroscience of visual perception.

He begins by dismissing his early realistic work of nature and the countryside as worthless and describes how he gradually moved away from 'natural aspects of reality', forsaking natural colour for what he called 'pure colour'. His painting of the Winkel Mill (figure 17) is one example of his early experiments with pure colour.

Figure 17: Piet Mondrian, 1908, *Mill in Sunlight: The Winkel Mill*, oil on canvas, 114 x 87 cm Bois et al, 1994, *Piet Mondrian*: 101.

Although the Harvard scientist Margaret Livingstone uses one of his late abstract paintings *Broadway Boogie-Woogie* (1942–43), as an example of how colours can appear to shimmer and leap from the canvas and goes on to give the scientific explanation for this effect, in my view he was already achieving something similar in The Winkel Mill, which he painted some thirty-four years earlier. The explanation for this is related to the luminance (or tonal) value of surfaces in the image. The visual brain uses the differences in luminance to localise discrete areas of the visual field, or in other words to define their boundaries. Colour is then assigned to each of these areas via a separate visual pathway. Therefore, when the luminance is the same or very similar, as in The Winkel Mill, the brain of the spectator cannot fix the colour to the appropriate section of the image, as the boundary between them is uncertain. The eye scans across the image in an attempt to correct this and as a result the colours appear to shimmer or vibrate.

(Livingstone, 2002:157)

On his first visit to Paris, before the outbreak of the First World War, Mondrian was influenced by the Cubists but later rejected their approach saying that Cubism:

> …did not accept the logical consequences of its own discoveries; it was not developing abstraction to its ultimate goal, the expression of pure reality.(Mondrian,1941, in Holtzman: 338)

The influence of the cubists in seeking new forms and a new reality can be seen when comparing two of his paintings, completed a few years before going to Paris in 1911, one of woods (figure18) and the other a seascape, (figure 20), with paintings completed in Paris of similar subjects, figures 19 and 21 respectively.

Figure 18: Piet Mondrian, *Woods near Oele*, 1908,oil on canvas, 128x158cm, Bois et al, 1994, *Piet Mondrian:* 100.

The colourful semi realistic scene of woodland in 1908 transforms into an abstract composition of geometric shapes, mainly triangles and rectangles that retains a sense of vertical branching forms, four years later.

Figure 19: Piet Mondrian, *CompositionTrees II*, 1912, oil on canvas, 98x65cm Bois et al, 1994, *Piet Mondrian:* 132.

Figure 20: Piet Mondrian, *Seascape,* 1909, oil on card, 34.5x50.5cm, Bois et al, 1994, *Piet Mondrian:* 109.

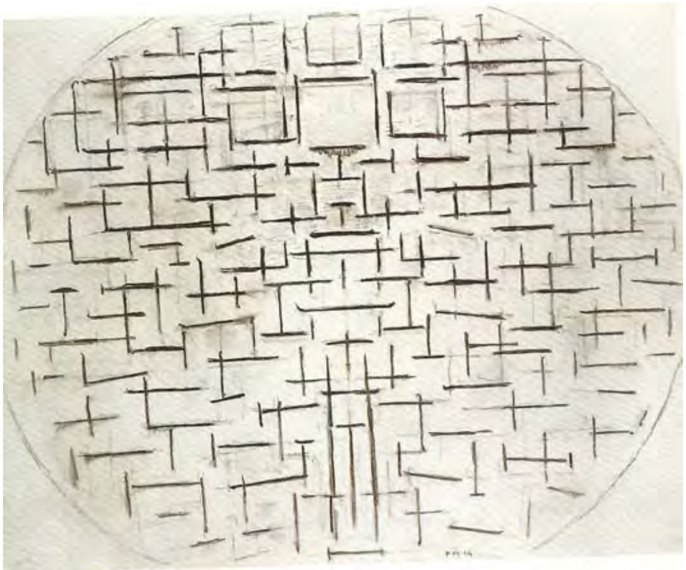

Figure 21: Piet Mondrian*, Pier and Ocean* 4, 1914,charcoal on paper, 50x63cm, Bois et al, 1994, *Piet Mondrian:* 164.

Similarly, in figure 21 Mondrian has advanced his quest to find constant elements of form and is clearly reducing the image to horizontal and vertical intersecting lines, a precursor of his later more famous works.

Mondrian then went on to develop his own theories of 'neo-plasticism' and in 1941 he defined 'purely plastic' thus:

> … the purely plastic is unconditioned by subjective feeling and conception…. To create pure reality plastically, it is necessary to reduce natural forms to the constant elements of form and natural color to primary color.

Applying a neuroscience interpretation to this in terms of finding the constant elements of form and primary colour, he is in harmony with what neuroscience has revealed about visual perception. Namely that the primary colours (short medium and long-wavelength light of the visible spectrum) are the basis of all ‘natural’ colour that we can perceive and which is constructed by our visual nervous system according to an inherited concept over which we have no control. It is interesting that his conclusion, that vertical and horizontal lines were constant elements, parallels the fact that the nerve cells that respond only to these orientations are the most represented throughout the visual cortex. In addition there are none that respond specifically to the curved line. Although objects and forms in the environment are not bounded by line, artists know that we recognize a representation of a form drawn in outline. Since all shapes of line can be constructed from the straight line I think it is reasonable to agree with Mondrian about the importance of the vertical and the horizontal as the building blocks of form.

The following quotes from his essay demonstrate his thoughts on his search for ‘equilibrium through a true vision of reality’.

> More and more I excluded from my painting all curved lines, until finally my compositions consisted only of vertical and horizontal lines,…..
>
> …vertical and horizontal lines are the expression of two opposing forces; these exist everywhere and dominate everything; their reciprocal action constitutes “life”.
>
> ….reality is form and space. Nature reveals forms in space. Actually all is space, form as well as what we see as empty space.
>
> Art has to determine space as well as form and to create the equivalence of these two factors.

> Feeling the lack of unity, I brought the rectangles together: space became white, black or grey; form became red, blue or yellow. Uniting the rectangles was equivalent to continuing the verticals and horizontals of the former period over the entire composition. (Mondrian, 1941, in Holtzman (Ed), 1987: 339)

These principles informed the grid paintings that dominated the latter part of his career and two examples are shown below, both from his second period in Paris illustrating the use of only black and white and primary colours and rectangles bounded by intersecting black lines.

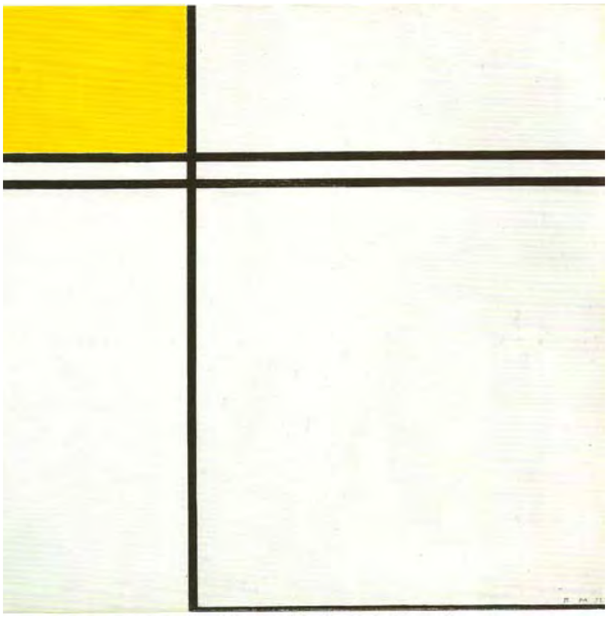

Figure 22: Piet Mondrian, *Composition with Yellow and Double Line*, 1932, oil on canvas, 45.3x45.3 cm, Bois et al, 1994, *Piet Mondrian:* 255.

Although Mondrian used the term Neoplasticism, one could say that he had been seeking the ultimate in abstraction towards the essence of line, form and colour. Towards the end of his essay Mondrian makes what is a most prescient statement when he says: ‘Plastic art discloses what science has discovered: that time and subjective vision veil the true reality.’ (Mondrian, 1941, in Holtzman (Ed), 1987*:* 341)

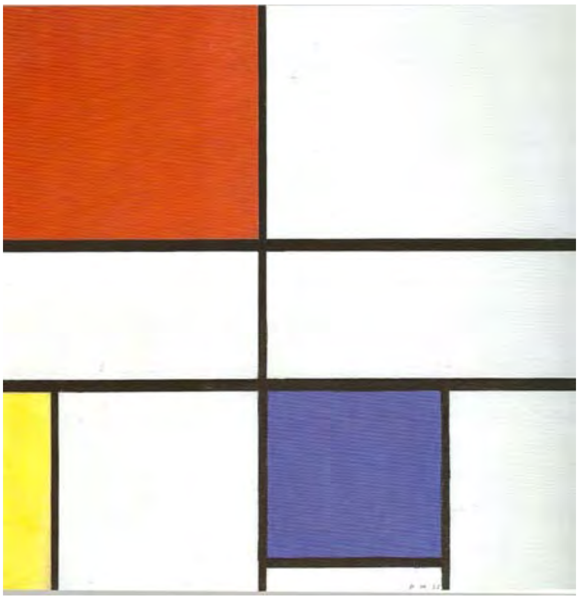

Figure 23: Piet Mondrian, *Composition with Red, Yellow and Blue*, 1935, oil on canvas, 56x55.2cm, Bois et al, 1994, *Piet Mondrian :* 261.

Neuroscientists can recognize distinct parallels between Mondrian's abstractive process and the ways in which the visual brain selects only the essential attributes of the visual field that are required to make sense of what we see. The squares and rectangles that dominate his late work are also prominent in the work of many other artists of the early twentieth century such as Kazimir Malevich, Ellsworth Kelly, Theo Van Doesberg and Mark Rothko.

Figure 24: Kazimir Malevich, *Red Square*, 1915, oil on canvas, 53x53cm, (below) and responses of a cell in V4 to blue square on white and black background (above). Zeki,1999: 121.

Figure 24 shows a cell in V4 responding to a blue square on a white background in its receptive field, on the upper right of the picture. There is no response to the same blue square on a black background when this is placed in its receptive field. The painting, *Red Square*, by Malevich is shown below by way of comparison with the shape of the receptive field. The observation that these shapes echo the shape of the receptive fields of visual cells in the cortex is one I find most intriguing. (Zeki,1999: 118-125) Could it be that the artist and in many cases the viewer of these works has a subconscious sense of satisfaction or balance in the composition because it is in harmony with a fundamental anatomical and functional configuration within our visual system? Perhaps this has something to do with the “pre-existing idea” of the artist discussed by Albert Gleizes and Jean Metzinger in their discourse on Cubism, *Du Cubisme*, published in 1912. Is it possible that this could have something to do with Mondrian’s sensation of equilibrium within his late works where he strove to find the configuration of rectangles and intersecting lines that seemed to be free of tension? Might this even have a bearing on the dominance of the rectangular shape as the frame within western art? Now I am an artist and not a scientist I am free to speculate. The following quote states the more objective view from neuroscience:

> 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 listed above (lines, squares and rectangles) will be responding vigorously. One can also state the converse that if cells of 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. (Zeki, 1999: 124-125)

Playing with concepts

Neuroscientists see one of the fundamental characteristics of the brain as the ability to form internal concepts, models or ideals of the three-dimensional world by assimilating and processing information from the sensory organs. They believe that in order to do this the brain needs to know the permanent, essential and constant properties of objects and surfaces and other attributes of the environment as a reference. (Zeki, 2002:1) In addition the brain is able to undertake operations to discount the changes in visual appearance that occur as an object moves through space, or is viewed from a different direction, or moves nearer or farther away and still recognize it as the same object. We also have concepts of objects through a description of them in words that conjure up an internal image in our imagination, and we can recognize the same object in a two dimensional photograph, drawing or painting, even though we are viewing it from only one direction.

Erich Harth, formerly Emeritus Professor of physics at Syracuse University, New York, researches the mechanisms involved in higher brain functions. He puts forward a convincing theory that the greatly enlarged prefrontal cortex, which is unique to the human brain, made possible the emergence of art and language, both of which require the use of concepts and symbols. He explains that our sensory pathways are reflexive, in that higher cortical centres control nerve activity at peripheral sensory areas. Fundamental to most cognitive functions, these 'recursive interactions between central symbols and peripheral images' are likened to an *'internal sketchpad'*. Harth believes that art and language developed as natural extensions of these processes as tools for thinking (Harth in Goguen (Ed.), 1999: 97). He includes an interesting story about Picasso, which highlights the arbitrary nature of pictorial representation and the two-way link with symbolic structures in our memory.

> …a man approached Picasso complaining about his painting Demoiselles d'Avignon. " Why don't you paint women the way they really look?" he wanted to know. "And how do they really look", Picasso asked. At that, the man pulled a photograph of his wife from his wallet, "Like this", he answered. Picasso studied the picture for a while and then handed it back to the man. "She's small, isn't she," he said, "and flat". (Harth, 1999: 97)

Figure 25: René Magritte, *The Betrayal of Images*, 1929,oil on canvas, 23 3/4" x 31 15/16 ".

http://www.artintern.net/update/english/200909/778c51eb4516292bbfeec61cd7d0a961.jpg

The Belgian surrealist, René Magritte (1898-1967), was another artist who played with our brain concepts of reality, images and illusions. In 1929 he challenged our interpretation of a two dimensional image as an object in his perfectly rendered oil painting of a pipe (figure 25) above a sign saying that this is not a pipe, which clearly contradicts the visual message. He was heavily influenced by the early twentieth century German philosopher Ludwig Wittgenstein, and his views on the relationship between thought, language and reality. In Wittgenstein's opinion thoughts and propositions are pictures, stating, *' the picture is a model of reality'.* (Biletski, 2011)

Nearly 40 years later, in 1965, Joseph Kosuth exhibited "three chairs" in his piece entitled *Wood folding chair, mounted photograph of a chair, and mounted photographic enlargement of the dictionary definition of "chair",* (figure 26 below). All three elements of the piece conjure up the concept of the "chair" in the mind of the viewer but there is only one they could sit on. This play between the visual and verbal language of representation invites the viewer to question their idea of reality.

Figure 26:Josef Kosuth, 1965. *Wood folding chair, mounted photograph of a chair, and mounted photographic enlargement of the dictionary definition of "chair",* Chair 32 3/8 x 14 7/8 x 20 7/8" (82 x 37.8 x 53 cm), photographic panel 36 x 24 1/8" (91.5 x 61.1 cm), text panel 24 x 24 1/8" (61 x 61.3 cm). http://www.moma.org/collection_images/

The painting, *Carte Blanche* (figure 27) is one example of Magritte's work where he sets out to confuse the viewer who is unable to determine in which plane the figure, the horse and the tree trunks lie in relation to the background. When the outlines of two objects cross, this normally acts as a cue for the brain that one lies in front of the other, but Magritte disrupts this with his visual trickery that makes it seem as though part of the horse may be transparent.

Figure 27: René Magritte, *Carte Blanche*, 1965, oil on canvas.
http://www.edgardegasgallery.org/upload1/file-admin/images/new23/magritte-823795.jpg

This illustrates an aspect of visual perception that is still a mystery to neuroscience, which is termed the binding problem. How does our visual brain interpret which elements in our field of view belong to each other and which do not? How are all the different modalities of vision brought together and how are the salient features selected when we are being bombarded with rapidly changing stimuli from a dynamic environment? (Zeki, 1999:128-131) It is also unclear how the brain integrates incoming visual data with cross-references to past experiences and memories, dreams and imagination and where this reaches consciousness, although it is assumed that the prefrontal cortex plays a key role in this executive control since this is greatly enlarged in humans compared with all other species. Harth believes that drawing and sculpture evolved in humans as mechanisms of thinking and problem solving, producing external symbols of ideas from internal mental images. (Harth, 1999:105-107) Although the immense complexity of integrated brain function is not understood, neuroscience is providing insight into our misconceptions about the interface between the subconscious and the conscious in terms of brain activity. Inevitably this challenges our understanding of free will, a subject which is beyond the scope of this dissertation. Some understanding of how our brains use visual imagery and how much conscious control we have over this process, however, must be of intense interest to the artist as it applies to the creative process.

Looking at a work of art has been assumed to be a conscious, sensory experience. A body of evidence now exists to confirm that we only have conscious awareness of the end result of a highly complex, multi-stage process, which is completed in milliseconds. Francis Crick (1916-2004), the molecular biologist and neuroscientist who received the Nobel Prize in 1962 for discovery of the DNA molecule, and Christof Koch (1956), Professor of Cognitive Behavioural Biology at CALTEC express this in their paper *'The Unconscious Homunculus, a discussion of intermediate level theory of consciousness*', thus:

> … we suggested that the biological usefulness of visual consciousness in humans is to produce the best current interpretation of the visual scene in the light of past experience, either of ourselves or of our ancestors (embodied in our genes), and to make this interpretation directly available - for a sufficient amount of time - to the parts of the brain that plan possible voluntary motor outputs of one sort or another, including speech.(Crick, Koch, 2000: 2)

In the body of the paper they discuss the nature of 'qualia', a philosophical term for the subjective conscious experience, or 'raw feel'; for example, blueness or saltiness. They describe how the term homunculus, (the little man inside our heads), has been given to our illusory internal image of ourselves, where we believe our consciousness resides. (Crick, Koch, 2000: 6*)* It is their opinion that the term unconscious homunculus is more appropriate, since we are unaware of most of the activity of our brains. Recently a number of eminent contemporary neuroscientists, appearing in a television programme examining free will, unanimously agreed that we are only aware of a tiny proportion of our brain activity at any given time, although we have an illusion of consciousness, and independent control of our thoughts and actions. (Horizon, 2012) When concluding their article, Crick and Koch summarise thus:

> …we are not directly aware of the outer world of sensory events. Instead we are conscious of the results of some of the computations performed by the nervous system on the various neural

> representations of this sensory world…. Nor are we directly aware of our inner world of thoughts, intentions and planning (that is, of our unconscious homunculus) but – and this is the surprising part—only of the sensory representations associated with these mental activities. What remains is the sobering realization that our subjective world of qualia—what distinguishes us from zombies and fills our life with colour, music, smells and other vivid sensations—is probably caused by the activity of a small fraction of all the neurons in the brain, located strategically between the outer and the inner worlds. How this activity acts to produce the subjective world that is so dear to us is still a complete mystery. (Crick, Koch, 2000: 8)

These thoughts about our sense of self in relation to art and aesthetics will be revisited in chapter four.

Chapter Three

Ambiguity - Emotion, Art and the Brain

Figure 28: Giotto Di Bondone, 1325, *Stigmatisation of Saint Francis*, fresco, 390 x 370 cm, Bardi Chapel, Santa Croce, Florence. www. casasantapia.com.

In 1817 in his book *Naples and Florence: A Journey from Milan to Reggio* Henri-Marie Beyle (a French writer whose pen name was Stendhal) described the overwhelming emotions he experienced after viewing the wealth of renaissance art (e.g. figure 28 above) available in the famous Franciscan basilica of Santa Croce, the burial place of Michelangelo and Galileo.

> I was ecstatic with the idea that I was in Florence, close to the masters whose tombs I had seen. Deep in the contemplation of sublime beauty, I reached the emotional point where we experience heavenly sensations. When I left Santa Croce, I had heart palpitations. The life flowed out of me and I was afraid I would fall. (Barnas, 2008)

It seems that many people have had a similar experience and some have required professional help to deal with the intense psychological effects. Dr Graziella Magherini, an Italian psychiatrist from Florence, has now seen over one hundred patients with ‘Stendhal Syndrome’, and published her findings in 1989 in her book *La Sindrome di Stendhal*. (Barnas, 2008) This is an extreme example of how the aesthetic experience of viewing a large volume of works of art, mostly with religious themes, can arouse intense emotions in susceptible individuals. Understanding where the power to produce an emotional response comes from should be of interest both to those who create works of art in the studio and those who view them.

As far as I am aware, the precise neuro-physiological mechanisms for Stendhal Syndrome have not been studied specifically, but modern research into visual perception is shedding light on what great artists have worked out through experimentation, namely that the most successful images are those that leave room for the imagination of the viewer to be engaged in their interpretation. Arthur Schopenhauer, the well-known 19th century German philosopher, wrote extensively on this aspect of aesthetics and this short quote from *The World as Will and Representation, Volume Two*, demonstrates his agreement that the imagination of the viewer is important.

> … through the work of art, everything must not be directly given to the senses, but rather only as much as is demanded to lead the fancy to the right path…., in art the best of all is too spiritual to be given to the senses; it must be born in the imagination of the beholder, although begotten by the work of art. It depends upon this that the sketches of the great masters often effect more than their finished pictures. (Schopenhauer in Zeki, 2009: 88,89*)*

It seems that when the stimuli reaching the brain can be interpreted in more than one way, the higher cortical areas in the fronto-parietal lobes are always actively engaged, bringing into play learning, memory, judgement and experience. It had been assumed that these higher centres were required as "top-down" processing sites to interpret perceptual information from other parts of the brain and to reach consciousness. However, it is now clear that different specialized areas of the visual cortex, for example colour, motion, shape and object recognition, are autonomous for these functions and operate independently unless the visual information is unstable or ambiguous. (Zeki, 2009: 63, 76-86) There are different levels of ambiguity when we look at works of art or aspects of our environment, ranging from the totally unambiguous such as colour, about which we have no conscious control, through those of doubtful ambiguity and the genuinely ambiguous or unstable imagery where there are multiple possible options.

The sensation of colour is a good example of an unambiguous stimulus. We have no choice about our perception of the colour of an object, which can only be interpreted by the brain in one way. (page 27) Some optical illusions play on the way the brain interprets illusory contours, visual imagery which is of doubtful ambiguity. A classic example is the Kanizsa Triangle, shown below in figure 29. In the interpretation of this shape configuration, all subjects see an upright triangle superimposed on an inverted triangle, even though they know that the upright triangle has not been 'drawn' in the same way as the other shapes.

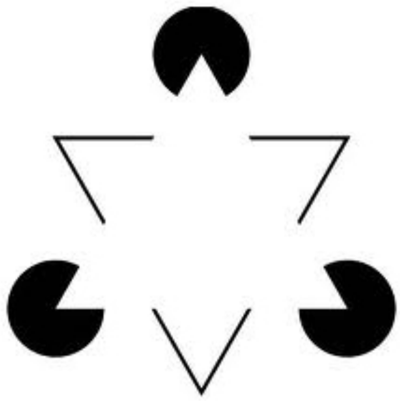

Figure 29: *Kanizsa Triangle*, Zeki, 2009: 75.

Simultaneous brain imaging shows activation in the posterior visual cortex (V1, V2 and V3), corresponding to the distribution of orientation-selective cells. These cells, as described earlier in chapter one, only respond to lines of a specific orientation and not at all to lines of the opposite direction. They have also been shown to respond to virtual lines, such as those which are "created" in the figure above. Since these cells can only respond to their preferred orientation of line, there can be only one interpretation of each part of the shapes. However in order to interpret this as a triangle with virtual borders, object recognition must also take place and indeed the lateral occipital cortex, another part of the visual system essential for object recognition, is also activated. Significantly, there is no activation of the higher centres of the fronto-parietal cortex and it is therefore evident that perception and processing, through to conscious recognition of the superimposed triangles, is taking place entirely within the reciprocally interconnected areas of the visual cortex. Zeki describes this as, a "physiological straightjacket, determined strictly by the rules of the brain" (Zeki, 2009: 74), which is not as immutable as colour assignment, but is still effectively open to only one interpretation. For more optical illusions see the competition website for 'Best Illusions of the Year'. (Martinez-Conde, 2005)

There are many other situations where visual stimuli are illusory or ambiguous and open to more than one interpretation. It seems reasonable to conclude that the capacity of the brain to recognize that there is more than one possible solution is another example of an inherited brain concept (see chapter one). Such a concept is very difficult to disrupt and can be regarded as a necessary protective mechanism to prevent the individual from making a potentially dangerous misinterpretation of sensory signals, for example trying to decide if an individual's demeanour is threatening or welcoming. (Zeki, 2009: 62-63)

Many artists have exploited this aspect of brain function. A straightforward example is the painting of the slave market (figure 30) by the Spanish surrealist, Salvador Dali (1904-1989), a visual joke in which he has created a "double image", which can be interpreted as either the bust of Voltaire by Houdon, or figures of women in black and white.

Figure 30: Salvador Dali, *Slave Market with the Apparition of the Invisible Bust of Voltaire*, 1940, oil on canvas, 46.5x65.5cm**. http://www.antiquity.tv/wp-content/uploads/2010/01/Salvador-Dali-1940-voltaire.jpg**

When considering high level ambiguity in visual art, the paintings of the seventeenth century Dutch artist, Johannes Vermeer (1632-1675), who has been the subject of considerable study from a technical and art history perspective, are often cited as good examples. Although, at first glance, his depictions of a typical domestic scene (figure 31) appear to be rendered in meticulous detail, in his essay, *Vermeer's Vision*, Martin Kemp, Emeritus Professor of the History of Art at Oxford University (b.1942), describes how, on closer examination of the painted surface, Vermeer's mastery in creating the illusion of realism is revealed. He states:

> He had learnt, by a hard-won process of pictorial trial and error, that when the artist wishes to cajole our perceptual system into collaborative action that less is definitely more.
> The hues and tones of the generalized patches of paint -virtually abstract on close viewing- are pitched with such deliberate skill within the spatial framework that we irresistibly see more than is actually there. (Kemp,2000: 32,33)

Figure 31: Jan Vermeer, *Woman in blue reading a letter*, 1662-65, oil on canvas, $18^{1}/_{4}$"x$15^{7}/_{8}$".
http://www.essentialvermeer.com/catalogue/woman_in_blue_reading_a_letter.jpg

The subject matter and composition of Vermeer’s paintings is of particular interest to Semir Zeki, when he discusses higher levels of ambiguity. He extrapolates from the view that the brain uses acquired concepts as short cuts to rapid interpretation of diverse stimuli, and uses the term “situational constancy” when considering the general aspects of the domestic scenes painted by Vermeer. From neurobiology it is not yet known how the brain processes situations, but it is assumed that we acquire concepts of situations we have experienced in our social and cultural environment, which are then used for reference. The pregnant woman quietly reading a letter in *Woman in Blue*, (figure 31), depicts a familiar domestic scene which would be recognized by the brain of the viewer as an acquired concept, or situation. The feelings of the woman reading the letter are not obvious from her enigmatic expression, so one can speculate on the content and the source of the letter. He believes the number of equally valid interpretations that can be made give the painting its power. By way of explanation, Zeki states:

> The genius of Vermeer is that he does not provide an answer but, by a brilliant subtlety, manages to convey all the expressions, although the viewer is only conscious of one interpretation at any given moment. Because there is no correct solution, the work of art itself becomes a problem that engages the mind. " Something, and indeed the ultimate thing, must be left over for the mind to do," wrote Schopenhauer. There could be no better illustration of this than the work of Vermeer, where nothing is explicit. (Zeki, 2009: 87)

He goes on to say:

> … memory, experience, learning and much else besides can influence what is perceived at any given moment. This almost certainly involves a "top-down" influence from diverse sources, not just the frontal lobes. Thus, opening up the capacity for a given brain area… to be influenced by multiple other areas and therefore by multiple concepts…. the artist exploits intuitively this potential of the brain that allows multiple areas to influence what is perceived. (Zeki, 2009: 91, 92)

In his view, since the visual part of the brain evolved long before the linguistic brain, an additional richness in visual art may exist in images which evoke ambiguous signals that are inaccessible through language. (Zeki, 2009: 92) There is evidence from neuroscience to support this and to explain why blurred, indistinct images are more powerful emotionally than clear ones. Patrick Vuilleumier, a Swiss neurologist, found that the amygdala, one of the brain regions involved in the processing of strong emotions such as fear, was activated strongly only when subjects looked at blurred as opposed to sharp images of the same face with a fearful expression. (Vuilleumier, 2003) When discussing this research, Patrick Cavanagh points out that, in contrast, the areas responsible for conscious familiar face recognition respond best to sharply detailed faces and only weakly to blurry faces. He cites previous research showing that even very brief, unconscious exposure to a fearful image can excite the amygdala and gives one example where a patient with no primary visual cortex (V1) and no conscious visual experience still showed right sided amygdala activation when presented with images of emotional facial expressions. (Cavanagh, 2005:305-306)

In her book *Mysteries of the Rectangle*, Siri Hustvedt ponders on what makes some works of art have such a profound effect on the viewer. Without reference to neuroscience, she also concludes that the key factor is the ambiguity within the image, which she links to the power of the work to generate an emotional response. (Hustvedt, 2005) Interestingly, one of the paintings she chooses is the deliberately blurred photo-painting *Uncle Rudi* (figure 32) by the German artist Gerhard Richter (b.1932).

Figure 32: Gerhard Richter, *Uncle Rudi*, 1965, oil on canvas, 87x50cm. Hustvedt, 2005: 152.

She explains that this painting is recognizable as a black and white photograph of a German officer but the visible brush strokes '…. create an athmosphere of partial erasure and dimness, as if he's in the process of vanishing.' She goes on to say:

> The artist has come between the photo that recorded someone in time and the spectator who is looking at its translation on a canvas. Uncle Rudi ..…. combines the documentary quality of the snapshot and its accompanying feelings of loss with the presence and dignity of traditional painting. Together they create a strain of doubt and ambiguity that simultaneously undermines and enhances the viewer's perception of the image. (Hustvedt, 2005:153,154)

The information from neuroscience would suggest that because of the blurring, a rapid and unconscious response (perhaps one of fear for those who are aware of the context of the German army uniform) could be evoked in the emotional centres of the brain before the higher centres have engaged in further analysis of the imagery at a conscious level. Similarly it is thought that the paintings of the French impressionists have an emotional impact, because the unrealistic painting style, or 'blurring', distracts conscious vision. (Cavanagh, 2005, 305,306)

Although I can agree with much of what Kemp, Zeki and Husvedt say about ambiguity, it seems rather simplistic to regard this as the key factor that induces an emotional connection with visual art. In my view there are many examples of where the context and the theme is very important, especially if the subject reflects an intense human experience. When the British sculptor Henry Moore (1898-1986) experienced the bombing of London in World War Two and sheltered in the tube under Liverpool Street Station, he was inspired to produce a series of powerful drawings (figures 33 and 34).

Figure 33: Henry Moore, *Tube Shelter Perspective-The Liverpool Extension,* 1941, pencil, ink, wax & watercolour on paper, 48.3 x 43.8cms. Stephens, 2010:174.

Anyone who is aware of the context, viewing these frail, ghostlike figures huddled together in semi- darkness in figure 33 and the mothers comforting their children in figure 34, would not find them ambiguous but would almost certainly find them a moving representation of human fear and despair. I believe that even without knowledge of the context, their power lies in the portrayal of universal themes of human distress and maternal love.

Figure 34: Henry Moore, *Women and Children in the Tube,* 1940, pencil, wax crayon, chalk, watercolour wash, pen & ink on paper, 27.9 x 38.1cms. Stephens, 2010:169.

One contemporary artist who certainly has exploited ambiguity in their art is the German painter and photographer, Sigmar Polke (1941-2010). Eva Schmidt, the curator of a major exhibition of Polke's work in 2007, discusses in some detail the technical aspects of his work that create a sense of ambiguity and wonder in the finished imagery. She starts by quoting Umberto Eco (b.1932), the eminent Italian writer and philosopher, from his views on ambiguity in art, which go hand in hand with those of Samir Zeki, even though Eco has no apparent knowledge of neuroscience.

> We are accustomed to regarding as artworks those objects which a) on the one hand force us to consider the way they were made and b) on the other hand leave us unsettled, since it is not altogether certain whether they really only "want to say" what they appear "to say". In this sense, then "ambiguity" cannot necessarily be reduced to deformation, stylistic innovation or a disruption of the expectations of the viewer; it can be all of that (and in contemporary art it is, or frequently has been),

> but above all it denotes a phenomenon such as “surplus of meaning” or “polysemy” or whatever you want to call it (or should we say “openness”). (Eco, 1988 in Schmidt, 2008: 15)

In the chapter *With a Magic Wand and Lenticulars- How a Wavering Universe of Visual Rhetoric is Born,* Schmidt analyses the allegorical work shown in Figure 35 entitled *The Illusionist.* She describes how the ‘surplus of meaning’ that Eco refers to arises not only from the multitude of puzzling characters and animals from the magician’s world inhabiting the painting, but also from the physical layers that make up the painting. He uses ‘the lenticular’ created with a layer of rippled milky transparent acrylic paint medium, which refracts light in different directions, distorting the images on the layers beneath and creating reflections, which add to the illusory quality.

Figure 35: Sigmar Polke, *The Illusionist*, 2007, lens-acrylic on fabric, 225x300cm. Schmidt, 2007: 75 & 76.

In my view much of the illusory power of the work comes from the sense of depth achieved by the semi transparent layers partially occluding parts of the figures. Polke manages to create a deep three-dimensional space inhabited by these fantastical beings, which gives the viewer the impression that they could lose themselves in the world within the painting. Polke approaches his art much like a scientist experimenting with the chemistry of materials and the physics of refraction and reflection of light through the layers within his work. Schmidt states that his mode of painting is

> ..anchored not in an (art-historical) history of painting, but in a history of experimentation and magic, both of which share a common origin in alchemy with its fusion of art, science and philosophy. (Schmidt, 2008: 15)

Prolonged examination is required to try to decipher the complexity of the combined imagery within many of his paintings. This work in particular would certainly fit a definition of advanced ambiguity, stimulating different areas of brain activity and drawing on multiple acquired concepts from memory and experience in order for the viewer to reach their own personal interpretation.

Recent television marketing research, using neuroscientific techniques, seems to confirm that a visual experience is more likely to be remembered, i.e. reach long term memory encoding (LTME) if there is emotional engagement with the imagery (Thinkbox 2012). The ability to create a long - term memory of their work within the mind of the viewer is clearly another attribute of visual imagery that an artist would like to understand and command. The Thinkbox research team explains the complementary roles of the two cerebral hemispheres in processing sensory information, which are diagrammatically represented in figure 36 below. Although this is applied to advertising in the visual media, the same principles apply to appreciation of other visual art forms. The cortex of the right hemisphere deals more with the general or subjective experience. It can rapidly process diverse information and make abstract connections between things, largely in our subconscious. If the subject matter is successful in stimulating feelings of empathy and an emotional response, then this corresponds to increased activity in the cortex of the right hemisphere. These responses are enhanced by colour, the addition of music and also positive facial expressions both in human beings, especially children, and animals whereas fearful faces suppress our attention. Without this experience the imagery is unlikely to be stored in long-term memory.

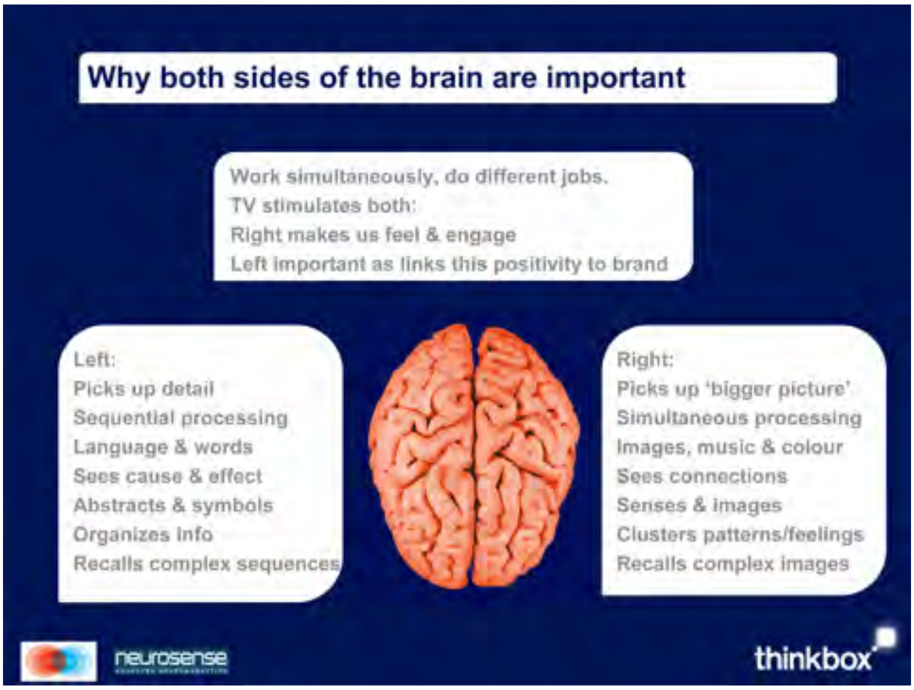

Figure 36: How the brain hemispheres differ in processing sensory information. Thinkbox, 2010.

Simultaneously, the left hemisphere, which deals with detail, sequential processing and language, is involved in the further analysis, understanding and organization of this information and the assignation of appropriate language to describe it.

In summary, neuroaesthetics is in its infancy and has yet to discover what happens when we view art of different genres, such as abstract expressionism. In this chapter I have selected the paintings of a small number of artists who I believe have been successful in stimulating an emotional response from their work either through a level of ambiguity in the narrative interpretation, the structure of the work or from the context and theme and where neuroscience has something relevant to say. It seems that images which are ambiguous and open to multiple interpretations and where facial expressions are indistinct are most likely to illicit an emotional response in the viewer. In addition, artists who use colour, and incorporate human or animal forms and expressions, with the addition of appropriate sound or music, increase the chances for fixation of the imagery in the long-term memory of the viewer. This then allows them to recall the aesthetic experience and share it with others.

The next chapter will concentrate more on the creative process undertaken by the artist, the concepts of “the ideal” and the “unfinished” and the possible links with aspects of the human psyche.

Chapter Four

Figure 37:Author, 2010, *Absence,* screen print

I feel that this chapter allows me to return to where I started when I realised that I could no longer trust my perception of the world. It also allows me to reflect on how my personal experience showed itself in my art. I remember feeling as though I had broken into pieces and had lost my sense of self, with only emptiness ahead (figure 37). I felt that I had to reassemble memory of my past life before I could exist again and face the future. It is fascinating to discover that new research suggests that the importance of memory may not be to keep hold of the past, but to give structure to the future. (Robson, 2012) I became my own case study experiencing the extraordinary sensation that one part of my brain could make quite lucid critical observations of the disordered thinking and actions orchestrated by another, as though I was several different beings at once. I know that my higher cognitive functions were not all grossly impaired since there was an occasion when I performed a long, complicated mathematical calculation in my head whilst I was experiencing a waking-dream. I wrote down and kept the answer and at a later stage, when fully awake, I repeated the calculation, which proved to be correct in every detail.

Since doing the research for this dissertation I have gained some insight into this sensation that there are co-existing islands of better functioning brain as well as dysfunctional ones. (figure 38)

Figure 38: Author, 2011, *Day One*, oil, wax and collage on canvas

Functional specialization seems to be a feature across the cerebral cortex as it is in the visual brain and this would provide a neuroscientific explanation for the autonomous function of different areas of cognition, as I experienced.

In his detailed long-term case studies of patients with localized brain injuries rather than psychological pathology, the American neurologist Oliver Sacks explores the complexity of the visual systems within the human brain and illustrates how specific functional islands are lost. He also includes numerous examples that illustrate the plasticity of the brain, adapting to loss of function by recruitment or retraining of other sensory systems to compensate for the loss. For example the writer who through a stroke lost his ability to read (alexia) and had memory problems but still had his internal imagination as a writer and could write. He trained himself to improve his memory by keeping a memory book and could “read” through touch and proprioception by tracing words with his fingers and eventually could return to his career. (Sacks, 2010: 53-81)

In my view there is no reason to suppose that a similar level of adaptation could not occur in other parts of the brain when thought processes and perception of the world are distorted through psychological trauma or alteration in brain chemistry. Were this true it would tend to support the views of some psychoanalysts that what others regard as mental illness is in fact a protective construct to allow that person to function within a certain context, a view that the psychoanalyst and writer, Darian Leader, expands in his discussion on the nature of madness (Leader, D., 2011). He also emphasizes the value of the individual approach to patients, which was standard before drug treatment developed, and which revealed examples of these ‘restitution mechanisms’, the pathways back into life. He calls into question the prevalent psychiatric approach that does not invest in a long-term interest in the patient’s experience as a human being. ‘The psychotic person has become less a person to be listened to than an object to be treated. .. The individual has vanished.’ (Leader, 2011: 4)

In a similar way in his other book, *The New Black* he states his view that priority is given to "medicalising" solutions without attention to the inner life of the sufferer and that depression is conceived as a biological problem to be got rid of rather than understood.

> *…..*people become emptied of the complexity of their unconscious mental life. Depression is deemed to be the result of a lack of serotonin rather than a response to experience of loss and separation. (Leader, 2011: 2,3)

Although I agree with the main thrust of his argument, taking into account my personal experience, I would favour the view that restoring the balance of essential neurotransmitters, such as serotonin, in addition to other therapeutic approaches, is helpful.

The innate drive of the brain to rapidly make sense of chaotic visual information, which I have discussed in detail in previous chapters, could help to explain the way modern psychiatry has concentrated on the biological model of depression and other mental illness and the widespread use of drugs to 'normalize' behaviour. They may simply be following the need to create a recognizable framework, 'making sense of complex patterns' and avoiding the more problematic work with an individual by treating them within diagnostic categories. In my view there is a risk that the more we attempt to intellectualise the workings of the human mind, which we do not understand, the further we get from the emotional world of the individual which is what makes us human and the more we make a human being into an object. Of course one cannot ignore the influence of the global pharmaceutical industry and the politics and economics of health care management on clinical practice.

A sense of loss of self or the loved one pervades mental illness and resonates with the loss of the individual in modern psychiatry and society as a whole. I find it interesting that Leader extols the value of the early terms of mourning and melancholia discussed by Sigmund Freud (1856- 1939) the Austrian neurologist and founder of modern psychoanalysis, but largely ignored in modern psychiatry. Leader regards depression as:

> ..a vague term for a variety of states. Mourning and melancholia, however, are more precise concepts that can help to shed light on how we deal – or fail to deal - with the losses that are part of human life. (Leader, 2011: 4)

He regards mourning as a shared experience involving cultural rituals focused on the deceased whereas the melancholic is attached to the loss itself, not the person they have lost, as though the absence or empty space is real and will engulf them. This loss of self and the emptiness experienced by the melancholic or depressive is a rich area for artistic expression. The British artist and sculptor Rachel Whiteread (b.1963) cast the empty space within an entire house (figure 39) and the American artist and photographer Bruce Nauman (b.1941) cast the empty space which bounded a table, rather than the table itself. Both gave substance to an empty space.


Figure 39. Rachel Whitread, "House". http://www.damonart.com/myth_uncanny.html

Leader continues with this theme: ‘ ..in so many cases of melancholia … it necessitates creating a new language to talk about loss.’(Leader, 2010: 201) and cites examples of patients who talk of how the ‘truth’ is not the same as the facts. The arduous process of communicating the impossible truth of their loss requires a ‘language’ and someone to receive that communication. As in mourning which also requires other people this communication can take the form of speech, touch, writing poetry, drawing, painting, making music i.e. ‘making art’. His contention is that works of art are made from nothing, and that perhaps in mourning we need to create this ‘frame for absence’ (Leader, 2010:208) as a means of finding equilibrium. I do wonder if this is what Mondrian was thinking of when he used the term equilibrium when he considered the composition of his paintings and his search for reality. This extract from his essay ‘Toward the True vision of Reality’ suggests this may be so:

> Reality only appears to us tragical because of the disequilibrium and confusion of its appearances. It is our subjective vision and determined position which makes us suffer. Although tragical manifestations and feelings exist only in time, for us human beings, time is reality. Our subjective vision and experience made it impossible to be happy. But we can escape the tragical oppression through a clear vision of true

> reality, which exists, but which is veiled. If we cannot free ourselves, we can free our vision. (Mondrian,1941, in Holtzman, 1987:341)

I can see a link between the loss that is at the heart of mourning, melancholia and much psychological trauma, and the basic principles of visual perception and therefore cortical function in the brain. In order to make rapid sense of the visual world we require a vast range of innate and acquired concepts of features of what we see and a cognitive process that utilizes and evaluates this information in context. At a higher level we may create a synthetic concept of who we are within the context of our family or our place in society based on our work, and when we do not meet the ideal of that construct we may feel failure or, if our role is taken away form us, a profound sense of loss of self. In a similar way an artist will have an internal concept or ideal of the work they wish to produce and more often than not find it impossible to reach that ideal in the finished work. In some cases the artist prefers to leave the work unfinished or may destroy it. Francis Bacon, (1909-1992) the Irish born British artist is a good example of one who commonly destroyed those paintings which were not sold, because he could never reach what he wanted in them.

> I think I tend to destroy the better paintings, or those that have been better…I try and take them further and they lose all their qualities, and they lose everything. (Bacon, in Sylvester, 1975:17)

When speaking about one of his most famous series of paintings, versions of the Velasquez *Pope Innocent X,* (figure 40) he minimizes their worth by saying:

Figure 40: Francis Bacon, 1963, *Study after Velasquez's Portrait of Pope Innocent X*, oil on canvas, 153x118cms. Leiris, M, 1987, plate 12.

> I've always thought that this was one of the greatest paintings in the world, and I've used it through obsession. And I've tried very, very unsuccessfully to do certain records of it – distorted records. I regret them, because I think they're very silly. (Bacon, in Sylvester, 1975: 37)

When asked about his early desire to produce the perfect image he suggests that the search for this elusive perfection is what keeps an artist going, when he says:

> …I hope to go on painting until I die and, of course, if you did the one absolutely perfect image, you would never do anything more. (Bacon, in Sylvester, 1975: 107)

Other artists who are dissatisfied with their inadequate efforts to realize their ideal image within their art leave their work in an unfinished state. Semir Zeki regards this is the highest level of ambiguity in that the viewer is given free reign to complete the work in whatever way they wish. He discusses the renaissance artist Michelangelo Buonarroti (1475-1564) as a famous example of an artist who left many of his works unfinished (in Italian, non finito), especially his sculptures. The Rondanini Pietà shown in figure 41 was worked on for many years and remained unfinished at the time of his death.

Figure 41: Michelangelo, *The Rondanini Pietà*, side view, http://jayebee.com/images/incompleteness/2.jpg

There seems to be fairly good evidence from those who knew him that it was a deliberate act to leave three fifths of his sculptures unfinished. Giorgio Vasari (1511-1574), a contemporary painter and friend of Michelangelo wrote:

> Michelangelo's non finito reflects the sublimity of his ideas, which again and again lay beyond the reach of his hands. (Vasari in Zeki, 2009:109)

From a personal viewpoint I have learnt not to expect my art to correspond to the internal image I may start with. Happy accidents happen and, particularly with paint, the work can take on a life of its own, occasionally reaching a stage when you are rewarded with a rush of satisfaction. I have often wondered why this positive perception of your own work is so fleeting, so that a piece of work you may be immensely proud of one day can appear worthless a few days later. Neuroscience may shed some light on what is happening here. In brain imaging experiments the orbito-frontal cortex, one part of an extensive reward system involving the cortex and sub cortex, is activated when subjects rate a painting as beautiful. Since the same painting does not produce this result in every subject, it is presumed that this reflects the individuals' aesthetic preference. (Zeki, 2009: 53,54) Powerful neuromodulators, especially dopamine, are released into the bloodstream associated with rewarding experiences and the formation of attachments between people and it is likely that this chemical plays a key role in maintaining the creative drive to attain the elusive ideal. Zeki explains the most recent research suggesting that

> ..dopamine is linked not only to reward itself but to the expectation of reward, and that its release correlates more with the desire than with the pleasure. The reward itself, when obtained, may not satisfy the synthetic concept in the brain, and biology has seen to it that as soon as a climax is reached, it turns immediately into an anti-climax. (Zeki, 2009: 175)

Brain imaging has also provided information that in my view suggests another reason why an artists' satisfaction with their work is only temporary. The universally common finding when mothers are shown an image of their child or when a subject is shown the image of their lover and reward centres of the brain that are activated, is that there is a pattern of cortical deactivation or suppression, especially in the area of the frontal cortex. This area is associated with the formation of judgements, suggesting a less critical and more tolerant attitude to the loved one. (Zeki, 2009:143,144) I would speculate that as an artist labours over their creation, they "fall in love" with the whole concept and that, in the same way, their critical judgement is temporarily suppressed when they look at it. With time, perhaps when the concept is less intense, clarity of critical thinking returns and perception of the work changes. Perhaps it will be possible in the future to track functional images of the artists' brain while they create a finished work and link this to their subjective view of the process. In the meantime, a quote by Lucian Freud (1922-2011), the famous German born British figurative artist illustrates these arguments quite well:

> A complete moment of happiness never occurs in the creation of a work of art. The promise of it is felt in the act of creation and disappears towards the completion of the work. For it is then that the painter realizes that it is only a picture he is painting. Until then he has almost dared to hope that the picture might spring to life. Were it not for this, the perfect painting might be painted, on completion of which the painter could retire. It is this great insufficiency that drives him on. That process of creation becomes necessary to the painter perhaps more than the picture itself. The process is habit-forming. (Lucian Freud, in Zeki, 2009:57)

So in the creation of a work of art, however transient the personal reward, we give substance to an empty space and create a framework for absence. We also create an image that may reflect and absorb our thoughts and feelings. At the same time the work becomes a literal and metaphorical screen separating us from an empty space. Francis Bacon believed that we live a screened existence:

> We nearly always live through screens- a screened existence. And I sometimes think, when people say my work looks violent, that perhaps I have from time to time been able to clear away one or two of the veils or screens. (Francis Bacon, in Sylvester,1975: 82)

Perhaps in the world of the depressive, adverse circumstances have torn down these screens leaving them unprotected from the infinite emptiness or void beyond.

Figure 42: Rembrandt, Harmensz van Rijn, 1645, *Girl at a Window*, oil on canvas, 81.6 x 61 cm, http://dulwichonview.org.uk/assets/uploads/2010/04/Rembrandts-Girl-at-a-Window-DPG163AFTER-CONSERVATION-Aug-05-web-detail.jpg

My father often told me that art was 'good for the soul' when we stood in front of Rembrandt's *Girl at a Window* (figure 42), his favourite painting. He had fought in the African and Italian campaigns of World War Two but never spoke of his experiences. With hindsight, I think he would probably agree with me that art is not just a screen but also a construction of an imaginary world which buffers us from the horrors and injustice of reality and helps us to survive.

Conclusion

I have attempted to examine aspects of the current knowledge about the visual system of the human brain and how this relates to examples of contemporary and historical artists. I have explored the concept of the artist as the first neuroscientist and the new evolving discipline of neuroaesthetics which is of particular interest to me because of my dual background, formerly in medical science and now as a visual artist. In my view neuroscience has provided the understanding of the basic building blocks of visual perception, which are not disputed. The testing of hypotheses extrapolated from this information related to aesthetics and artistic practice is now being explored in the domains of cognitive psychologists and neurophysiologists through their collaboration with artists. Although this new discipline is in its infancy in terms of knowledge and understanding it is already possible to compare brain activity of an artist making a simple drawing with an untrained individual drawing the same figure (Solso, 2001) and, using hyperscanning techniques, to record synchronous fMRI from two individuals as they interact (McNamara, 2011). Increasing sophistication of the technology should make it possible to learn what happens when artists engage in the creation of their work over considerable time, a truly fascinating prospect.

I see visual art as the evolutionary ancestor of external written language. They are both cognitive tools evolving along interlinked but different pathways. There is a general consensus across disciplines that it was only at the time of transition from Homo erectus to Homo sapiens approximately 0.3 million years ago that the human brain and laryngeal structures were sufficiently developed to support speech and language (Donald,1993:738). When compared with visual communication, which had been evolving over millions of years, language as a communication tool was still in its infancy at the time our artist ancestors were painting the animals on the walls of the Caves of Chauvet, 35000 years ago. Representational drawing, mark making and construction of artifacts has allowed us to communicate our inner thoughts and feelings as well as to record events and aspects of our environment creating an external memory, long before we could use spoken words to describe them. This gives me some comfort when I am unable to engage with critical writing about works of art and their attributes.

It seems logical to concur with Zeki's belief that the visual brain is simply better equipped than the linguistic system to extract the essentials of an image. He states that:

> …the visual system is able to detect a great deal in a fraction of a second- the state of mind of a person, the colour of a surface, the identity of a constantly changing object. A small inflection here, a spot of paint there, can make a difference between a sad or a happy face because the brain has developed a quick and highly efficient system of visual recognition. (Zeki,1999:9*)*

The process of writing this dissertation has brought the artificial divide between art and science into sharp focus on a personal level. My scientific training demanded rigorous attention to objective analysis of the evidence base when writing about a subject and a minimum of personal opinion, observation and hypothesis. This is in sharp contrast to the approach of artists or philosophers who are used to considering the subjective and the abstract.

As a consequence my internal conflict in trying to shift my writing style towards that of the artist has provided an interesting parallel with the heated debate in academic circles about the new neuroscience and neuroaesthetics and its place alongside art and creative practice. It is probably inevitable, given my background, that I do not see neuroaesthetics as a threat to artistic expression and creativity, but more as a positive way forward to increase knowledge about the human condition. Though some may view this as a potential threat to their beliefs, I believe it will provide inspiration to artists and increase our wonder at the complexities of the human mind, its development and powers of recovery.

All I have discovered confirms that we are at the beginning of a path illuminating the intricacies of how our own brains acquire and use knowledge. In the short term these insights will undoubtedly have far reaching consequences not only for artists and their practice but also for our cultural belief systems. In the longer term they may well form the basis for the next major transition in the development of human cognition

Bibliography

Books

Anand. M.R., 1978, *Seven Little-Known Birds of the Inner Eye*, Japan, Charles E. Tuttle Co., Inc.

Aunger. R., 2002, *The Electric meme,* New York, The Free Press.

Bahn. P., 2007, *Cave Art: A Guide to the Decorated Ice Age Caves of Europe,* London, Frances Lincoln Ltd.

Baker, E., (Ed.) 1935, New English Dictionary, Odhams Press Ltd., London.

Blackmore. S., 2000, *The Meme Machine, Oxford, oxford University Press.*

Bois, Y-A., Joosten, J., Rudenstine, A., Janssen, H., 1994, *Piet Mondrian*, Little Brown & Co, Canada.

Boot. M. Et al, 2002, *Grayson Perry – Guerrilla Tactics*, Amsterdam, Uitgever.

Collins. J., Mayblin. W., 2005, *Introducing Derrida,* Cambridge, Icon Books Ltd.

Dawkins. R., 1989, *The Selfish Gene,* Oxford, Oxford University Press.

Dawkins. R., 1999, *Unweaving the Rainbow,* London, Penguin Books.

Dawkins. R., 2006, *The God Delusion*, London, Bantam Press.

Dissanayake. E., 1988, *What Is Art For?* Washington, Washington University Press.

Escholier, R., 1960, *Matisse from the Life*, R.MacLehose & Co Ltd, The University Press, Glasgow.

Farthing, S., (Ed) 2010, *Art the Whole Story*, London, Thames & Hudson.

Gasché. R., 1986, *The Tain of the Mirror, Derrida and the Philosophy of Reflection,* London, Harvard University Press.

Gogue, J., & Myn,E., (Eds.) 1999, *Art and the Brain,(* Journal of Consciousness Studies: Controversies in Science and the Humanities*)*, Volume 6 (1999): June/July.

Gogue, J., & Myn,E., (Eds.) 2000, *Art and the Brain, II: Investigations into the Science of Art* (Journal of Consciousness Studies: Controversies in Science & the Humanities), Volume 7, No. 8/9 (2000).

Gogue, J., & Myn,E., (Eds.) 2004, *Art and the Brain part III,* (Journal of Consciousness Studies: Controversies in Science and the Humanities), Volume 11, No. 3/4 (2004).

Hockney. D., 2006, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters,* London, Thames and Hudson Ltd.

Holtzman, H., James, M., (Eds.) 1987, *The New Art – The New Life: The Collected Writings of Piet Mondrian*, Thames and Hudson, London.

Hustvedt. S., 2005, *Mysteries of the Rectangle*, New York, Princeton Architectural Press, 153-156.

Jones. W., 2006, *Grayson Perry- Portrait of the Artist as a Young Girl,* London, Chatto and Windus.

Jung. C.G., 1963, *Memories, Dreams, Reflections*, London, Collins and Routledge & Kegan Paul.

Jung. C.G., 1979, Man *and His Symbols,* Aldus Books

Kemp, M., 2000, *Visualisations : The Nature Book of Art and Science*, Oxford University Press, Oxford, UK. pp 2, 32-33.

Laing. R.D., 2010, *The Divided Self,* London, Penguin Group (Modern Classics), 37.

Leader. D, 2004, *Stealing the Mona Lisa: What Art Stops Us From Seeing,* UK, Shoemaker & Hoard.

Leader.D, Groves. J., 2010, *Lacan: A Graphic Guide,* London, Icon Books Ltd.

Leader. D., 2009, *The New Black: Mourning, Melancholia and Depression*, London, Penguin, 193,194.

Leader. D., 2011, *What is Madness?* London, Hamish Hamilton for Penguin.

Leiris, M.,1987, *Francis Bacon,* Ediciones Poligrafa S.A., Barcelona.

Livingstone, M., 2002, *Vision and Art: The Biology of Seeing,* New York, Harry N Abrams.

Plato, *The Collected Dialogues of Plato: Including the Letters (Bollingen Series LXXI)* Hamilton, E and Cairns, H, (Eds), Princeton University Press, Princeton, 2005.

Riley, B., M., 1997, *Mondrian: Nature to Abstraction*, Tate Gallery, UK.

Sacks. O., 2010, *A man of letters*, in *The Mind's Eye*, London, Picador, 53-81

Schmidt, E., 2007, With a Magic Wand and Lenticulars; How a Wavering Universe of Visual Rhetoric is Born. In Schmidt, E., von Velsen, N., Eds. *Sigmar Polke: Wunder von Siegen*, Dumont, Germany, 2009, pages 14-17.

Sylvester, D., 1975, *Interviews with Francis Bacon*, Thames and Hudson, London.

Zeki, S., 2009, *Splendors and Miseries of the Brain; Love Creativity and the Quest for Human Happiness*, UK, Wiley-Blackwell.

Zeki, S., 1999, *Inner Vision; An Exploration of Art and the Brain*, Oxford, Oxford University Press.

Articles and Journals

Atran. S., 2001, The Trouble With Memes :Inference Versus Imitation in Cultural Creation, *Human Nature* 12(4): 351-381, 2001.

Berrol. C F., 2006, Neuroscience meets dance/movement therapy: Mirror neurons, the therapeutic process and empathy. *The Arts in Psychotherapy*, 33, (2006): 302-315.
URL: http://www.adta.org/Resources/Documents/Berrol-2006.pdf (08/03/2012)

Blackmore. S., 2001, Evolution and Memes: The human brain as a selective imitation device, *Cybernetics and Systems*, Vol 32:1, 225-255, 2001.

Boyd, R., and Richerson, P.J., 2000. Meme theory oversimplifies cultural change. *Scientific American.* 283: 70–71

Brain Briefings, 2008, Mirror Neurons, *Society for Neuroscience*, November 2008.URL: http://www.sfn.org/briefings (08/03/2012)

Cavanagh, P., 2005. The artist as neuroscientist, *Nature*, vol 434, pp 301-307, 17 March 2005.
URL:http://visionlab.harvard.edu/members/patrick/PDF.files/2005%20pdfs/ArtistsasNeuroscientists.pdf (06/10/2012)

Cavanagh, P., Chao, J and Wang, D., Reflections in art, *Spatial Vision*, Vol. 21, No. 3–5, pp. 261–270 (2008).
URL: http://lpp.psycho.univ-paris5.fr/pdf/2092.pdf (06/10/2012)

Cavanagh, P., Visual cognition, *Vision Research*, 51 (2011) 1538–1551.
URL:
http://cavlab.net/wpcontent/uploads/2009/07/cavanaghviscognition2011.pdf (07/10/2012)

Dennett. D., 1990, Memes and the Exploitation of Imagination, The David and Miriam Mandel Lecture, American Society for Aesthetics, October 27, 1989, 47th Annual Meeting, in *Journal of Aesthetics and Art Criticism*, 48: 127-35, Spring 1990.
URL: http://ase.tufts.edu/cogstud/papers/memeimag.htm (20/02/2012)

Dennett. D., 2005, From Typo to Thinko: When Evolution Graduated to Semantic Norms. In: Levinson. C., and Jaisson. P., Eds, *Evolution and Culture.* The MIT Press, 133-145.
URL: http://ase.tufts.edu/cogstud/papers/dennett_from_typo_to_thinko.pdf (19/03/2012)

Donald. M., 1993, Précis of Origins of the Modern Mind: Three stages in the evolution of culture and cognition, *Behavioural and Brain Sciences,* (1993) 16, 737-791.
URL:http://psycserver.psyc.queensu.ca/donaldm/reprints/precis1993partA.PDF (19/03/2012)

Gallese, V., et al, 1996, Action recognition in the premotor cortex, *Brain*, 1996, 119; 593–609.

Griggs. J., 2010, Windows to the Mind, *New Scientist,* 18/09/2010, 34-39.

Haggard. P., et al, 2002, Voluntary action and conscious awareness, *Nature Neuroscience*, Volume 5, no. 4, April 2002pp 382-385.
URL: http://neurosci.nature.com (01/03/2012
Huang, M., The Neuroscience of Art, *Stanford Journal of Neuroscience,* Volume II, Issue 1, Fall 2009, 24-26.
URL: http://www.stanford.edu/group/co-sign/Huang.pdf (06/10/2012)

Ishizu, T., Zeki, S., (2011) Toward A Brain-Based Theory of Beauty. *PLoS ONE* 6(7): e21852. doi:10.1371/journal.pone.0021852
URL:http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0021852 (11/10/2012)

Kawabata, H., Zeki, S., (2008) The Neural Correlates of Desire. *PLoS ONE* 3(8): e3027. doi:10.1371/journal.pone.0003027
URL:http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0003027 (11/10/2012)

Kilner, J.M., et al, Evidence of Mirror Neurons in Human Inferior Frontal Gyrus *The Journal of Neuroscience*, 12 August 2009, 29(32):10153-10159; doi:10.1523/JNEUROSCI.2668-09.2009
URL:http://www.jneurosci.org/search?submit=yes&y=0&fulltext=review%20of%20mirror%20neurons&x=0&FIRSTINDEX=0 (08/03/2012)

Libet. B., 1999, Do We Have Free Will? *Journal of Conciousness Studies*, 6, No. 8-9, 1999, pp. 47-57. URL: http://www.imprint-academic.com/jcs (01/03/2012)

Livingstone. M. S., 2011, "Stereopsis and Artistic Talent: Poor Stereopsis Among Art Students and Established Artists*",* in *Psychological Science,* 22, 336-338.

Meng, M., et al, Lateralization of face processing in the human brain, *Proceedings of the Royal Society, B, Biological Sciences*, abstract published on line January 2012.URL: file:///Users/ann/Documents/GSAyr4/references:articlesdissyr4/Lateralization%20of%20face%20processing%20in%20the%20human%20brain.webarchive (08/10/2012)

Mukamel. R., et al, 2010, Single-Neuron Responses in Humans during Execution and Observation of Actions, *Current Biology*, 20, No. 8, April 27 2010, pp 750-756.
URL: http://download.cell.com/current-biology (08/03/2012)

Poulshock. J., 2002, The Problem and Potential of Memetics, 22/03/2002, *Journal of Psychology and Theology.*
URL: http://www.thefreelibrary.com/_/print/PrintArticle.aspx?id=85047453 (11/02/2012)

Ramachandran, V. S., Hirstein, W.,
The Science of Art A Neurological Theory of Aesthetic Experience, *Journal of Consciousness Studies*, 6, No. 6-7, 1999, pp. 15–51
URL:http://www.imprint.co.uk/rama/art.pdf (17/112012)

Robson,D., Memory, the ultimate guide, *New Scientist*, 06/10/2012: 33.

Schredl M, Frauscher S, Shendi A, Dream recall and visual memory, *Percept Mot Skills,* 1995 Aug; 81(1):256-8.

URL: http://www.rzuser.uni-heidelberg.de/~ly8/research/T008.html (06/10/2012)

Schütz-Bosbach. S., et al, 2006, Self and Other in the Human Motor System, *Current Biology*, 16, 1830-1834, September 19, 2006.
URL: http://keck.ucsf.edu/~houde/sensorimotor_jc/SSchutzBosbach06a (01/03/2012)

Silberstein, R. B., Schier, M. A., Pipingas, A., Ciorciari, J., Wood, S. R. and Simpson D. G. (1990) Steady state visually evoked potential topography associated with a visual vigilance task. *Brain Topography* .3: 337-347

Solso, R, L., Brain Activities in a Skilled versus a Novice Artist: An fMRI Study *Leonardo*, February 2001, Vol. 34, No. 1 , Pages 31-34 URL:http://www.jstor.org/stable/pdfplus/1576979.pdf?acceptTC=true

Sperber. D., 2000, An Objection to the Memetic Approach to Culture. In: Aunger, R., ed. *Darwinizing Culture: The status of Memetics as a Science,* Oxford, Oxford University Press, 163-173.
URL: http://www.dan.sperber.fr/wp-content/uploads/2009/09/meme.pdf (19/03/2012)

Vuilleumier, P., Armony, J.L., Driver, J., & Dolan, R.J. (2003), Distinct spatial frequency sensitivities for processing faces and emotional expressions, *Nature Neuroscience*, *6*, 624–631.

Zeki. S., 2002, Neural Concept Formation & Art: Dante, Michelangelo, Wagner, *Journal of Consciousness Studies,* 9, no. 3, 2002, pp. 53-76.
URL: http://neuroesthetics.org/publications.php002 (08/03/2012)

Zeki. S., 1998, Art and the Brain, *Dædalus*, 127, No.2, pp71-103.
URL: http://neuroesthetics.org/publications.php002 (08/03/2012)

Zeki. S., 2001, Artistic Creativity and the Brain, *Science,* Vol. 293, 6 July 2001.
URL http://neuroesthetics.org/publications.php002 (08/03/2012)

Zeki. S., 2002, Trying to Make Sense of Art, (Book review) Vision and Art: The Biology of Seeing by Margaret Livingstone, *Nature*, Vol. 418, 29 August 2002, pp 918,919.
URL: http://www.nature.com/search/executeSearch?sp-c=25&sp-s=date_descending&sp-q-1=NATURE%2CNEWS&sp-q=Zeki (08/03/2012)

Zeki, S., Romaya, JP., (2008) Neural Correlates of Hate. *PLoS ONE* 3(10): e3556. doi:10.1371/journal.pone.0003556
URL:http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0003556 (11/10/2012)

Zeki, S., Romaya, JP., (2010) The Brain Reaction to Viewing Faces of Opposite- and Same-Sex Romantic Partners. *PLoS ONE* 5(12): e15802. doi:10.1371/journal.pone.0015802
URL:http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0015802#s4

Internet

Arts and Humanities Research Council., 12/2011, News, AHRC project exploring the science of visual perception. (Research by Mariano Molina and Rodrigo Quian Quiroga)
URL: http://www.ahrc.ac.uk/News-and-Events/News/Pages/AHRC-project-exploring-the-science-of-visual-perception.aspx (06/10/12)

Allen. P.S., 2009, M R Research Centre -Functional MRI.
URL:http://www.invivonmr.ualberta.ca/Education/fmri.php (20/11/2011)

Barnas, M., Confrontations: An interview with Florentine psychiatrist Graziella Magherini, Metropolis M, Issue N° 4 2008 August/September

URL: http://metropolism.com/magazine/2008-no4/confrontaties/english (06/11/2012)

Belliveau JW, Kennedy DN, McKinstry RC, Buchbinder BR, Weisskoff RM, Cohen MS, Vevea JM, Brady TJ, Rosen BR. Functional mapping of the human visual cortex by magnetic resonance imaging. *Science*. 1991 Nov 1; 254(5032): 716-9.
http://www.ncbi.nlm.nih.gov/pubmed/1948051 (13/01/2013)

Biletzki, Anat and Matar, Anat, "Ludwig Wittgenstein", *The Stanford Encyclopedia of Philosophy (Summer 2011 Edition)*, Edward N. Zalta (ed.), URL: http://plato.stanford.edu/archives/sum2011/entries/wittgenstein/ (08/01/2013)

Blackmore, S. 1998. Imitation and the definition of a meme*. Journal of Memetics* - Evolutionary Models of Information Transmission, 2.URL: http://jom-emit.cfpm.org/1998/vol2/balckmore_s.html (11/03/2012)

Blackmore,S. 2007.Imitation makes us Human. URL: http://www.susanblackmore.co.uk/Chapters/human.pdf (11/03/2012)

Blumberg, J., Dartmouth Professor Offers New Insights on Left Brain/Right Brain Paradigm. Report of research by Assistant Professor Ming Meng, Dept of Psychological and Brain Sciences, Dartmouth College, NH, USA. Posted on January 4, 2012. URL: http://now.dartmouth.edu/2012/01/dartmouth-professor-offers-new-insights-on-left-brainright-brain-paradigm/ (07/10/2012)

Brown, M. 2009, Tate Modern puts void in Turbine Hall. URL: http://www.guardian.co.uk/artanddesign/2009/oct/12/tate-modern-turbine-hall-balka (08/03/2012)

Calvert, G., Williams, S., 2012, Into the deep: an introduction to Neuroscience. URL: http://www.thinkbox.tv/server/show/nav.1374 (07/11/2012)

Cavanagh, P., Gregory's 1977 paper-Comments-Alls jazzy and unstable on the colour front: the impact of Gregory's' pioneering paper on vision and equiluminance. URL:http://lpp.psycho.univ-paris5.fr/pdf/2677.pdf (06/10/2012)

Chalmers,D.J., 1995, Facing up to the problems of consciousness, *Journal of Consciousness Studies* 2(3):200-19, 1995.
URL:http://consc.net/papers/facing.html (19/03/2012)

Collins English Dictionary – Complete and Unabridged, 2003, HarperCollins, London.
URL: http://www.thefreedictionary.com/draw (08/01/2013)

Crick, F., Koch, C., 2000, The Unconscious Homunculus, in "*The Neuronal Correlates of Consciousness*", Metzinger, T., ed., pp. 103-110. MIT Press: Cambridge, MA (2000) URL: http://www.klab.caltech.edu/~koch/unconscious-homunculus.html (19/03/2012)

Cunniff, T., 2005, Book Review, The Void in Art by Mark Levy.
URL: http://www.stretcher.org/features/books_the_void_in_art/ (08/03/2012)

Davies, L., 02/03/2009, Paris Hosts New Exhibition of Nothing.
URL: http://www.guardian.co.uk/artanddesign/2009/mar/02/pompidou-centre-vides-exhibition (08/03/2012)

Dawkins. R., 1991, Viruses of the Mind.
URL: http://cscs.umich.edu/~crshalizi/Dawkins/viruses-of-the-mind.html (20/01/2012)

Deasy. H., From the Great Humpty Dumpty Disaster to the Emperor's New Meme.
URL: http://thegreatdebate.org.uk/Deasy1.html (14/03/2012)

Distin. K., 2005, an extract from *The Selfish Meme: A Critical Reassessment*, Cambridge University Press.
URL:http://www.cambridge.org/servlet/file/store6/item2376285/version1/item_9780521606271_excerpt.pdf (21/03/2012)

Finkelstein. R., Kruse. A., 2008, A Memetics Compendium. URL: http://www.semioticon.com/virtuals/memes2/memetics_compendium.pdf

Friend, T., 2001,Health and Science, “Culture’s not only human”.
http://www.usatoday.com/news/science/2001-06-05-animal-usat.htm
(08/03/2012)

Henson. H K., 2002, Sex, Drugs, and Cults: An evolutionary psychology perspective on why and how cult memes get a drug-like hold on people, and what might be done to mitigate the effects. Published in *The Human Nature Review,* 2002 Volume 2: 343-355(23August)
URL**:** http://human-nature.com/nibbs/02/cults.html (14/03/2012)

Herzog, W., Werner Herzog on the Birth of Art (Interview), 2011, *Archaeology Magazine,* Volume 64, Number 2, March/April 2011.
URL:http://www.archaeology.org/1103/features/werner_herzog_chauvet_cave_forgotten_dreams.html (17/03/2012)

Hyman,J., Art and Neuroscience, in R. Frigg, M.C. Hunter (eds.), *Beyond Mimesis and Convention*, Boston Studies in the Philosophy of Science 262, DOI 10.1007/978-90-481-3851-7_11,
URL:http://hoot.queens.ox.ac.uk/academics/hyman/files/art_and_neuroscience.pdf (17/11/2012)

Marneli. M., 2005. Review of: Kate Distin, *The Selfish Meme: A Critical Reassessment*, Cambridge University Press, 2005, 238pp, $21.99 (pbk), ISBN 0521606276. In *Notre Dame Philosophical Reviews*, an online journal, 16/09/2005.URL:http://ndpr.nd.edu/news/24865-the-selfish-meme-a-critical-reassessment/

Martinez-Conde, S., 2005, yearly to present
URL: http://illusionoftheyear.com/ (14/02/2013)

McNamara**.** A., 2011, Can We Measure Memes? Published 25 May 2011, Perspective Article, *Frontiers in Evolutionary Medicine.*

URL: http://www.frontiersin.org/Evolutionary_Neuroscience/ (11/02/2012)

More 4: What Makes a Masterpiece? (Tate Britain + University of Leicester 26/01/2012)
URL:http://www.youtube.com/watch?feature=player_detailpage&v=2juwr-xoVfY
(08/10/2012)

Preti, A. and Miotto, P. 1997; Creativity, Evolution and Mental Illnesses, *Journal of Memetics* - Evolutionary Models of Information Transmission, 1.
URL:http://www.cpm.mmu.ac.uk/jom-emit/1997/vol1/preti_a&miotto_p.html

Richerson. P., Boyd. R., 2005, Culture Is Essential. An excerpt from *Not By Genes Alone: How Culture Transformed Human Evolution.* 2005,The University of Chicago Press.
URL:http://www.press.uchicago.edu/Misc/Chicago/712842.html

Rizzolati. G., 2005, The mirror neuron system and its function in humans. *Anat Embryol* (2005), 210: 419–421. Published online: 13 October 2005, Springer-Verlag.
URL:http://www.telefonica.net/web2/lupelandia/piramidescerebro/The%20mirror-neuron%20system%20in (19/03/2012)

Rosenberg, J. 2012, The Mona Lisa Was Stolen!
URL: http://history1900s.about.com/od/famouscrimesscandals/a/monalisa.htm
(08/03/2012)
The Man who Forgot to Read and Other Stories, Imagine, Spring 2011, BBC iPlayer. Interview with Oliver Sacks.
URL: http://www.bbc.co.uk/programmes/b012b42j (20/11/2011)

Thinkbox, 2010, Neuroscience: creativity, media placement and the brain. URL: http://www.thinkbox.tv/server/show/nav.1367 (7/11/2012)

Velmans, Max (1997) Is my unconscious somebody else's consciousness? A review of D.Chalmers (1996) *The Conscious Mind: in search of a fundamental theory,* Oxford University Press. [Journal (Paginated)]
URL:http://cogprints.org/386/1/CHALMERS.html (19/03/2012)

Zeki.S., Stutters. J., 2012, A brain-derived metric for preferred kinetic stimuli. *Open Biology*, 2012,2, 120001.
URL: http://rsob.royalsocietypublishing.org/content/2/2/120001.full.pdf
(08/03/2012)

Exhibitions

The Force and Form of Memory, 2011, Compass Gallery, Glasgow.

The Tomb of the Unknown Craftsman, 2011, Grayson Perry, The British Museum, London.

DVD

Goya: Crazy like a Genius, DVD. Robert Hughes

Television

Grayson Perry and the Tomb of the Unknown Craftsman, Imagine. Presented by Alan Yentob. 2011. TV, BBC. (BBC1, 1/11/2011)

Horizon: Out of Control? People like to think they are in control of their lives – what they feel and think. But scientists are now discovering this is often simply an illusion, 2012, TV, BBC. (BBC 2,13/03/2012)

Presentations/Lectures

Borgatti, M., Art is Wrong: How your brain tells you beautiful lies. URL:http://www.youtube.com/watch?feature=endscreen&NR=1&v=CzM1q6YgYtQ (08/10/2012)

Cavanagh, P., 2010, *Painting is a kind of line.* URL:

http://www.worldsciencefestival.com/videos/a_painting_is_a_kind_of_line

(28/01/13)

Cavanagh.P., 2012, *The Artist as Neuroscientist.*
Friday Seminar Series, 09/03/2012, Department of Psychology, Glasgow University.
Further information from-
URL:http://visionlab.harvard.edu/members/patrick/cavanagh.html

Martinez-Conde, S., *Faithful Resemblances* - TAM 2012 (Sep 20, 2012 by James Randi Foundation) URL: http://www.youtube.com/watch?v=ipikz1I_JcQ (08/12/2012)