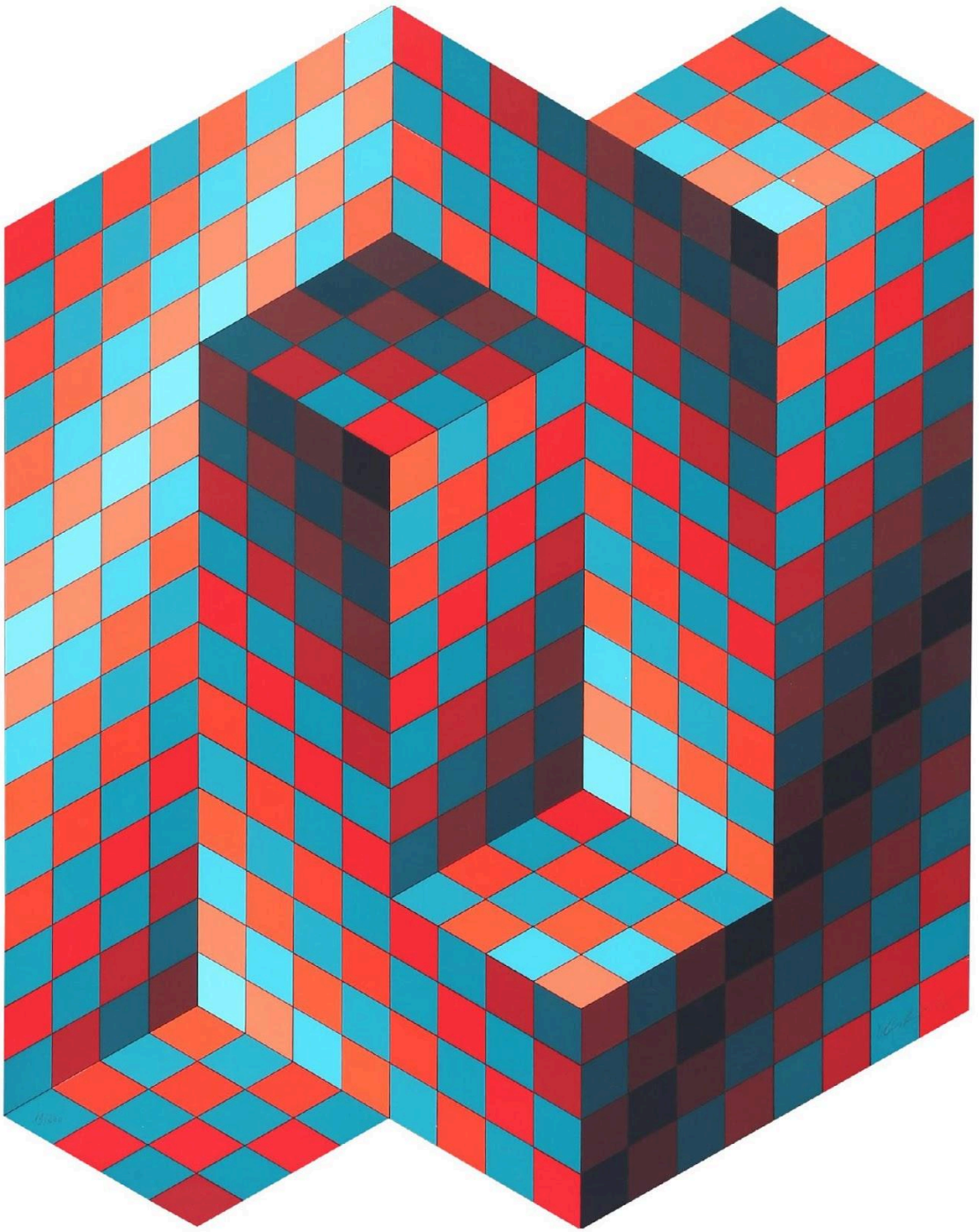
Minimalism and the Modular Mind



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Understanding the science of visual perception is highly valuable because it will better inform the creation of art. Engaging with two separate fields of research, the minimalist art movement and neuroaesthetics, as well as Eric Kandel's theory of Reductionism, this paper examines the experience of perceptual art.

Art that isolates one or two visual elements, as is the case in the pared back aesthetic of Minimalism, can promote a more direct experience because of the modularity of visual processing in the primary visual cortex. Minimalism marked a shift in art from object to experience. The value of abstract art in particular is considered as exposure to novel stimuli creates new associations which are formed as neural pathways. More hypotheses about the visual scene are generated, which leads to an increased neural involvement. This is likely to be beneficial for cognitive growth.

Op Art created perceptual visual disturbances through the creation of artificial depth in 2D pattern; this is demonstrated in work by painters Bridget Riley and Victor Vasarely. New Generation sculptors Michael Bolus and David Annesley took simple stripes, shapes and pattern and applied them as a skin of paint to 3D form. These artists are important to my practice as a sculptor because I am thoroughly interested in pattern. As part of my research I also interviewed artist Susan Aldworth, a lecturer on the Art and Science MA at St. Martins and Anya Hurlbert, a professor of visual neuroscience and the 2010-2018 Science Trustee at The National Gallery.

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Introduction

This dissertation will examine the experience of perceptual art and how minimalist artists of the 1960s worked to resolve visual components, employing some of the same methods that the neural system uses through the separation and reduction of optical elements. This research will engage with two separate fields of study: the minimalist art movement and neuroaesthetics, as well as Kandel's 2016 theory of reductionism.

Minimalism and Modularity

Minimalism marked the shift in experiencing art as an imagined pictorial space to an awareness of one's own body and relationship to physical material. This changed art from an object to an experience, which sparked many new movements after minimalism including installation and performance art. In examining this topic this dissertation will uphold the distinction Sol LeWitt once made between conceptual and perceptual work and focus solely on perceptual art.

> *Art that is meant for the sensation of the eye primarily would be called perceptual rather than conceptual. This would include most optical, kinetic, light and colour art. (LeWitt, 1967)*

The artists discussed in this text, apart from Vasarely, were not thinking or writing about vision science, but they were constantly experimenting in the studio[1].Unwittingly the pared back minimalist art they made exploited the way the human neural system processes visual stimuli. On the lowest levels of processing visual elements like colour, scale, orientation and contrast edges are split up (Anya Hurlbert, 2018). For example there are groups of cells that only process colour and there are group of cells that only process motion (Zeki et al., 1991) and once these separate features are processed, they are put back together and understood at higher levels of processing (Woodruff, 2017) in the frontal and temporal lobes. Although the process of seeing and recognising something only takes about one fifth of a second (Mather, 2013, p. 65) because of the way the brain processes visual scenes in this modular way, considering one or two elements in isolation can promote a very direct aesthetic experience (Livingstone, 2008)(Mather, 2013)(Zeki, 1999).

Neuroaesthetics

The significance of aesthetic preference, visual memory and emotional response are often overlooked in art criticism but:

> *The structure and function of the visual system determine the nature of all visual experience (Mather, 2012 p. 15)*

[1] In an interview artist Susan Aldworth discussed her creative process and admiration for the methodology that scientists use: '*I do think of an artist's studio a bit like a scientist's lab nowadays… as a place of experimenting'* (Aldworth, 2018)

Neuroaesthetics[2] is a new field of research which started in the 1990s. In 1991 Semir Zeki coined the term and argued that a truly comprehensive understanding of visual artmust incorporate an understanding of the thing that makes it (Zeki, 1999) Researchers so far in this field have considered the brain in relation to representative painting by old masters[3] but barely at all in the examination of modern abstract art or sculpture.

> *Discussions of visual art and aesthetics have omitted serious considerations of the role of the brain (Maher, 2013 p. 14)*

Methodology

In my dissertation I will examine how the brain processes and separates visual information, apply this knowledge to minimalist art and use Eric Kandel's theory of reductionism to support the idea of a direct aesthetic experience. By harnessing this understanding, artists canexploit the visual system and cause a specific response. For example, the way we experience motion when looking at a Futurist work(Blake and Kim, 2007) or colour upon viewing a work by the Fauves(Birren, 1976). The same theory and effect can be applied to the principals of minimalist art. Two sculptural practitioners that can be considered as archetypes of this outcome are Michael Bolus and David Annesley. Work from the

[2] 'the scientific study of the neural bases for the contemplation and creation of a work of art' (McClure and Siegel, 2015)
[3](Huang et al., 2011) examining activation of cortical areas while viewing Rembrandt paintings, (Cinzia and Vittorio, 2009) reviewing the field of neuroaesthetics by compiling the results of many neural studies where participants were shown classical representational paintings and sculptures,(Vartanian and Goel, 2004) evaluating the neuroanatomical correlation of aesthetic preference for paintings)

Op Art movement similarly played with perception but in a different way, by way of using illusions to cause visual disturbances. The two major theories of what happens in your brain when you look at Op Art (magnification and fluctuating accommodation) are exemplified in the work of Bridget Riley and Victor Vasarely who were the masters of this style. Finally I will consider the value of abstraction, implications it has on memory and object recognition for visual art and how this can be beneficial for cognitive growth. While researching these topics I conducted two interviews, one with artist Susan Aldworth, who makes art about the workings of the mind and our sense of self, and the other with vision scientist Anya Hurlbert, who researches the perception of colour.

How the Brain Processes and Separates Visual Information

Visual processing begins with an image entering through the cornea in the eye, which is projected onto the retina (the light sensitive tissue lining the back of your eye) and this information is passed to the occipital lobe in the brain via the optic nerve (see Figure 1). The mechanics of vision are just the first step in visual perception. ‘Perception means resolving ambiguity’ (Martinez-Conde et al., 2012). At higher levels of processing in the frontal and temporal lobes information is amalgamated to form an understanding.

At the lowest levels of visual processing in the occipital lobe(see Figure 2) visual elements are split into colour, form, movement, depth and spatial organisation (Changeux, 2012). Semir Zeki discovered that the V4 area processes colour (Zeki et al., 1991) and area V5 processes motion (Zeki, 2004)

> *The potency of certain forms of modern abstract art, which one might call sensory art, depends in part on their ability to isolate and amplify the raw sensory qualities that are signalled by specific populations of neurones in the occipital cortex. (Mather, 2013, p. 39)*

This is an important distinction to build upon and through this understanding that the brain splits up visual elements for processing, there can be many advantages for the visual arts. For example, futurism was an art movement in the early 20th century which ‘expressed the idea of the dynamism, the energy and movement, of modern life’ (Tate, 2018). In an experiment, (Blake and Kim, 2007)subjects were shown examples of futurist paintings. Although the paintings were stationary, the cells in their brains that interpret motion were activated. The fauvist paintings of the 1900s by artists like Matisse, Derain and Braque, focused mainly on colour (see Figure 3). These artists were not vision scientists but still they had a deep understanding of the way that people experience colour. This is supported by scientific evidence that was produced some 85 years later, in which colour was shown to be the visual element that was processed the fastest in the brain, preceding motion by 80 milliseconds (Zeki and Moutoussis, 1997). Therefore a strong use of colour, or another element that is selective to a specific

area in the brain during visual processing, in art can promote a very direct and distinct experience:

> *Visual attributes that are singled out for modular processing have primacy in visual art (Mather, 2013)*

This is supported by (Zeki, 1999a) and (Livingstone, 2008) and it is these ideas that I'd like to explore further by considering the influence of Kandel's theories on reductionism in the 20th Century art movement Minimalism.

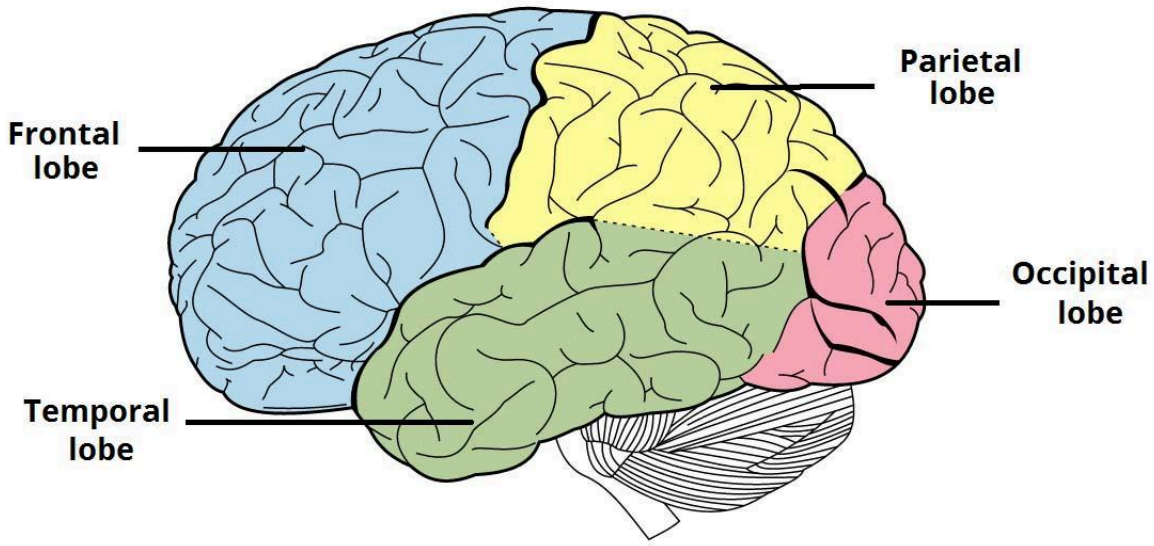

Figure 1The Lobes (Boeree, 2006)

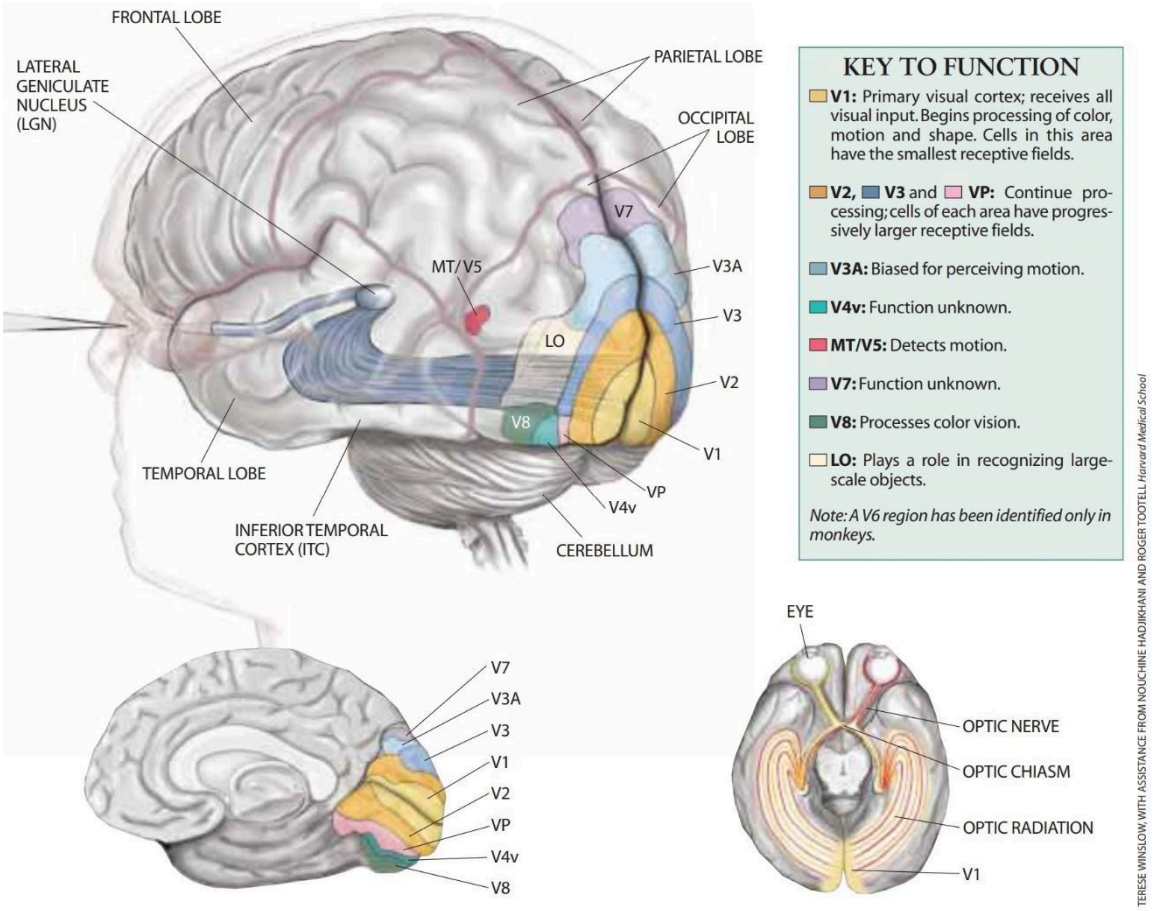

Figure 2Visual Processing Centre (Logothetis, 1999)

Minimalism and Kandel's Theory on Reductionism

Minimalism was an abstract art movement that developed in the 1960s and which celebrated the agency of simplicity in geometric form 'to allow the viewer an immediate, purely visual response' (Sampaolo, 2017)

It included abstract painters Ellsworth Kelly and Frank Stella and sculptors Anthony Caro, Donald Judd and Robert Morris, who often worked with industrial materials. Kynaston McShine, the curator of Primary Structures, a seminally important minimalist exhibition held in MOMA in 1966, wrote in his exhibition catalogue introduction:

> *Simplicity in structure allows for maximum concentration and intensity and does not necessarily imply vacuity; it usually, in fact, connotes a rich complexity of formal relationship and of experience(Mc Shine, 1966)*

McShine's assertion was that because the work of the minimalists applied no traditional decorative elements the viewer was forced to focus on pure form, colour and material. There was no implied meaning or representation, as there had been before in movements like Abstract Expressionism, which was about spontaneous gesture.

One of the leading artists of the Minimalist art movement Donald Judd (see Figure 4) believed in visual reduction as a methodology for his art practice

> *It isn't necessary for a work to have a lot of things to look at, to compare to, to analyse one by one, to contemplate. The thing as a whole, its quality as a whole is what is interesting. The main things alone are more intense, clear and powerful(Judd, 1965)*

Figure 3Sorrows of the King by Henri Matisse (Matisse, 1952)

Figure 4 Donald Judd, Untitled, 1965, plexiglass and cold rolled steel

Eric Kandel (b. 1929) is an Austrian Nobel prize winning neuroscientist who is known for his work on understanding the mechanisms of memory storage. To interpret the complexities of memory in the human brain, he focused on Aplysia[4],a simple sea snail which has the largest nerve cells in the animal kingdom. His discoveries around the creation and retention of memories and the biological distinction between short and long term memories were ground breaking. To understand this convoluted process in humans, he focused on a much simpler animal. He writes about this tactic as ‘reductionism’, which he has applied to both art and science as:

> *The distillation of larger scientific or aesthetic concepts into smaller, more traceable components (Kandel, 2016)*

Kandel has written two books about the overlap between art and science.In 2018 he wrote the book ‘Reductionism in Art and Brain Science: Bridging the Two Cultures’ which focused on abstract art. In particular, the parallels between the neural visual processing system and the way that minimalists from the 1950s New York School of Art movement worked to pare down visual elements in their artwork. He applied his reductionist methodology to their abstract art as a way ‘to perceive an essential component of a work in isolation, be in form, line, colour, or light’ (Kandel, 2016)

Why is this valuable? The focus is on the work in front of the viewer to create their own interpretation without reference to external knowledge. This encourages active participation and allows space for the projection of the viewer’s own thoughts, experiences and emotions. Experiencing abstract art can enable a

[4] The artist Henri Matisse made a collage of a snail ten years earlier using twelve cut out pieces of coloured paper to represent the movement and form of the creature by the simplest means (see Figure 5.)

momentary detachment from reality as the mind builds new hypotheses and narratives.

> *The very abstraction of an image gives us a certain detachment from reality, and this encourages top-down free associations, which we find rewarding (Kandel, 2016)*

Figure 5L'Escargot – Henri Matisse, 1953

New Generation Sculpture

Although minimalism began in New York in the 1950s, Britain wasn't far behind. Anthony Caro was an important leading figure and innovator in the 1960s British minimalist sculpture movement. Following a trip to America in 1959 he began to produce 'startling new works assembled using brightly painted steel sections to create improvisatory and open abstract sculptures.' (Rudd, 2017) Then in 1966 he represented Britain at The Venice Biennale and won the David E. Bright Foundation Prize for excellence in sculpture. Bridget Riley describes upon seeing a new work of his from that time, 'Early One Morning' (see Figure 6.) as if it were 'a painting that has been pulled out of its frame' (Rudd, 2017) Caro brought this new and influential approach into his role as a teacher at Central St. Martins.

Caro's influence spread far and wide. Many of Caro's students became celebrated sculptors: Tim Scott, William Tucker, Phillip King, Richard Deacon, Michael Bolus and David Annesley, and they were known as The New Generation Sculptors. David Annesley and Michael Bolus were both included in the 1965 *New Generation* show at the Whitechapel Gallery. In 2002 the Whitechapel Gallery held a commemorative exhibition called *Tra-la-la: British Sculpture in the Sixties* which featured work by the same artists, the original 'New Generation sculptors' ("Tra la la," 2002) Witkin, Annesley, Bolus Tucker and King.

The work on show in the 1965 exhibition was radical at the time. For example, the sculptures were brightly coloured and they were placed directly onto the ground without any plinths, commanding the same space as the viewer. The sculptors' use of brightly coloured paint acts like a skin on the surface of the work – there was no tactile or textural association, instead concentrating on visual significance. And though the exhibited works were made of welded steel and other heavy materials like plastic, aluminium and fibreglass, because of their 'scaffold-like construction' (Gompertz, 2008) they gave the appearance of being weightless.

Figure 6Anthony Caro, Early One Morning, 1962, steel and aluminium

Figure 7Anthony Caro, Month of May, 1963, steel and aluminium painted

David Annesley and Michael Bolus

David Annesley (b. 1936) has discussed his ‘kinaesthetic response to colour’ (Parsons, 2017) and the strong use of line as a defining factor in his work (see Figures 8 and 9). Often colour matching for weeks and repainting his works, he worked intuitively with colour. He trained as a pilot in the RAF and once described the shapes he used as follows: ‘The lines of my sculptures can be flown by miniature aeroplanes. If you rolled out a carpet behind a plane in flight – that’s the shape’ (Parsons, 2017). Annesley had begun his studies as a painter but eventually went on to teach in the sculpture department at St Martins. However his painterly concerns can clearly be seen through his use of colour in relation to his sculpture.

Anneley’s work is relevant to my practice as a sculptor because I have a strong interest in line and pattern. My research into the science of perception and optical illusions has prompted questions into the interpretation of depth. I am drawn to the tension between 2D pattern and 3D sculpture. To me, work by Bolus and Annesley is part sculpture and part graphic design because of their use of bold flat applications of colour and high contrast edges. They draw on the psychedelic, colourful patterns of the 1960s in an uncluttered minimalist way. The value of abstraction and how the unfamiliar can increase the viewer’s participation in an artwork to create an interesting aesthetic experience is something that fascinates me.

Michael Bolus (1934 - 2013) also brought a sense of painting to his sculpture. He used an application of bold colour onto metal to explore the themes of flatness and balance (see Figures 10 and 11). His sculpture ‘lies on the floor, often hugging it the way modern paintings hug walls’ (Lynton, 1968) Bolus was also interested in the extension of form, cutting into his painted steel sheets and bending them. His work was abstract and non-representative ‘shunning not only all references to other things but also all tendencies to individual expression’ (Lynton, 1968).

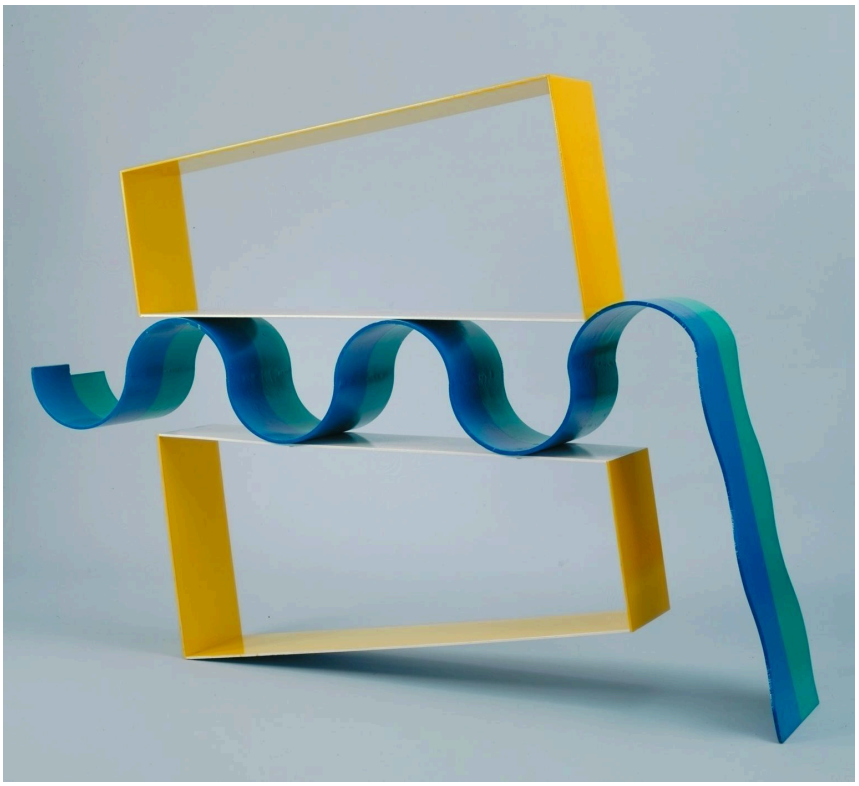

Figure 8David Annesley Swing Low, 1964, welded steel

Figure 9 David Annesley, 2017/2018 exhibition at Waddington Custot

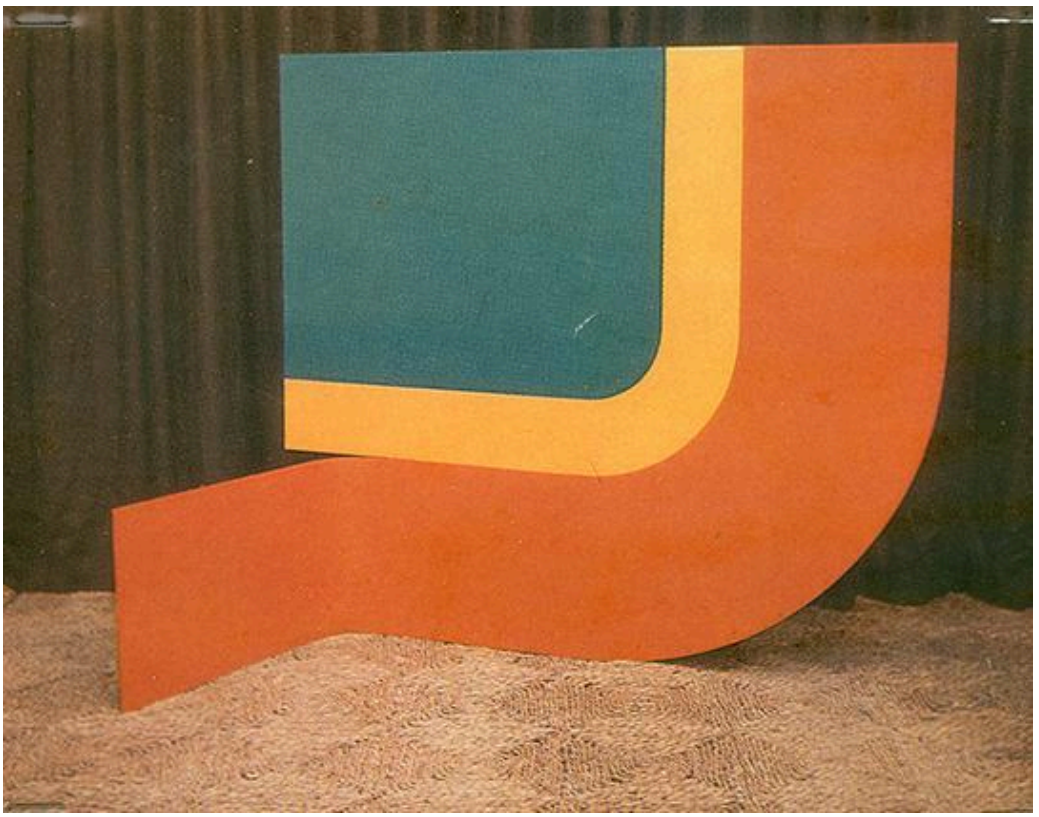

Figure 10Micheal Bolus, Bowbend, 1964, painted aluminium

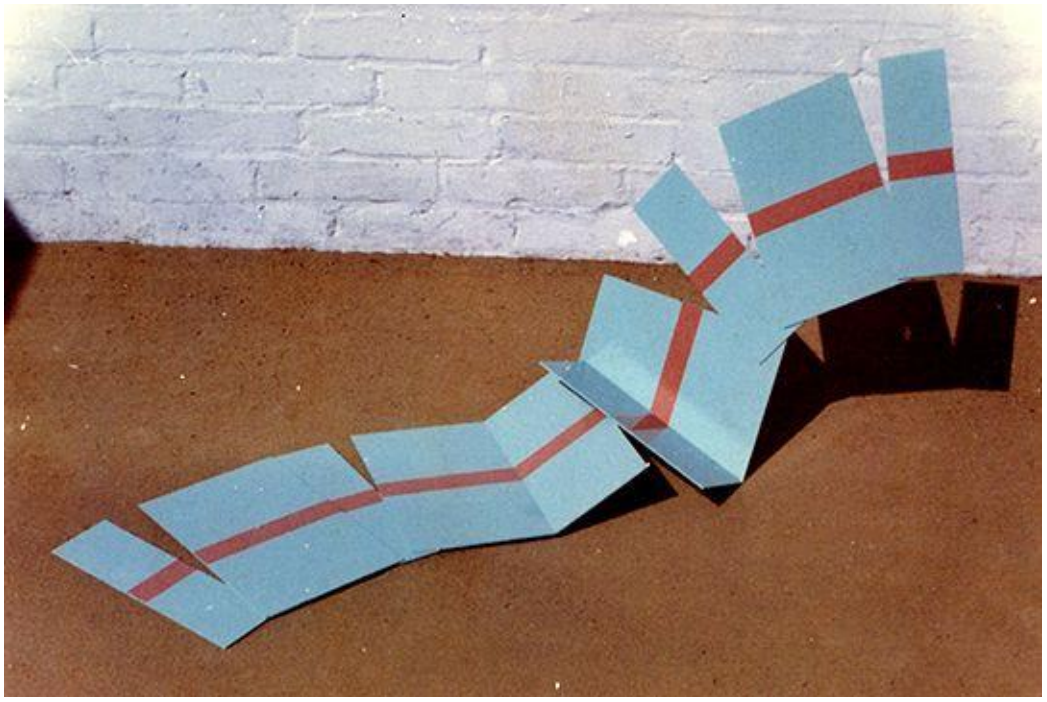

Figure 11Micheal Bolus, 11th Sculpture, 1963, polychrome metal

Op Art

Op Art (an abbreviation for optical art) was a style of abstract art using optical illusion that influenced many artists working in painting in the 1960s. Key artists involved included Bridget Riley, Isia Leviant, Victor Vasarely, Jesus Raphael Soto and Heinz Mack. These artists often used optical effects, geometric principals involving pattern and colour theory to create visual illusions.

Joe Houston, the curator of the 2006 exhibition *Optic Nerve: Perceptual Art of the 1960s* at The Columbus Museum of Art described it as 'art that heads directly to the nervous system and draws attention to our own process of seeing and believing' (Houston, 2007) He also mentions how influential to these artists MOMA's 1965 *Responsive Eye* exhibition was, curated by William C. Seitz, a seminal show for the movement. The exhibited works explored visual perception and illusion. In his catalogue introduction Seitz asks:

> *What are the potentialities of a visual art capable of affecting perception so physically and directly? (Seitz, 1965)*

Directing the viewer to the mechanisms of vision was deliberate and the interaction of eye and nervous system produced a variety of visual phenomena in the artwork, including effects like moiré, lens distortion and illusory motion.

> *It is clear how close to the border of science and technology some of the hard core optical works are (Seitz, 1965)*

The show at the time received a strong, favourable response from the public, and the exhibition sold out before it even opened with over 180,000 visitors. However, it was not as popular among critics. Clement Greenberg, at the time the most influential American art critic, dismissed it as 'novelty art' along with pop art and minimalism (Greenberg, 1995, p. 254). He preferred modernist painting, championing Willem de Kooning and Jackson Pollock and calling Abstract

Expressionism ‘the first great American art movement’ (Greenberg, 1955). Minimalism began as a reaction against Abstract Expressionism, stripping down all decorative elements and personal expression involved in action painting. Michael Fried, another art critic and friend of Greenberg was not a fan of Minimalism. In his 1967 text *The Objecthood of Art* (Fried, 1995) he accused the Minimalist artists of embracing the objecthood of art. But this was actually the intention of the minimalists: to make objects that interacted with real space. Donald Judd explained this idea, that real space is more powerful than imagined pictorial space in his text *Specific Objects* (Judd, 1965). Fried thought this physical object presence was theatrical. But the public reaction favoured this physicality and is still popular nearly 50 years later across many movements: Installation Art, Light and Space, Arte Povera, Young British Artists of the 1980s and 1990s and Land Art / Site Specific Art.

What Happens in Your Brain When You Look At Op Art

There are two possible explanations for the visual disturbances caused by looking at op art. The first is magnification. Eyes are constantly moving (these involuntary movements are called ‘microsaccades’ and happen 3 – 4 times a second). When the eye is constantly moving over a complex pattern with finely spaced lines or waves, these ‘changes in focus produce very slight changes in image magnification which may produce visual disturbances’ (Mather, 2013, p. 107).

The second explanation is called fluctuating accommodation. The muscles in the eye work to adjust focus when objects move. They squeeze and stretch the lens until the image is in focus. When the eye is struggling to decide which focal plane to focus on, some of the muscles begin to move slightly out of sync. Exploiting something of this phenomena Bridget Riley called her paintings ‘multifocal’, ‘not fixed to a single focus’ (Gottesman, 2016). This could explain the ‘shimmer and jazzing in certain op art patterns’ (Mather, 2013, p. 107).

Further to this, the use of high contrast patterns is a key component in Op Art, whereby the imagery is split into the chromic channel that represents colour and the achromic channel which represents luminance, both of which are necessary for neural processing.

The eye is also naturally drawn to salient areas that contain the most detail - they do not fixate on flat planes of gradient colour. Therefore they are drawn to the part with ‘the highest density of features such as edges and bars, or having the highest local contrast’ (Itti and Koch, 2000). Contrast is important for all forms of sensory cognition – as it helps us make a spatial 3-D sense of the world: ‘without it, the world would have no boundaries and your brain could make no sense of itself or anything outside itself’ (Martinez-Conde et al., 2012, p. 12).

Within the Op Art movement artists found they could exploit illusions to create a compelling sense of disorientation, and that these effects are ‘necessarily perceptual, not optical’ (Mather, 2013, p. 106), meaning they can confuse our understanding of our sense of spatial depth or orientation.

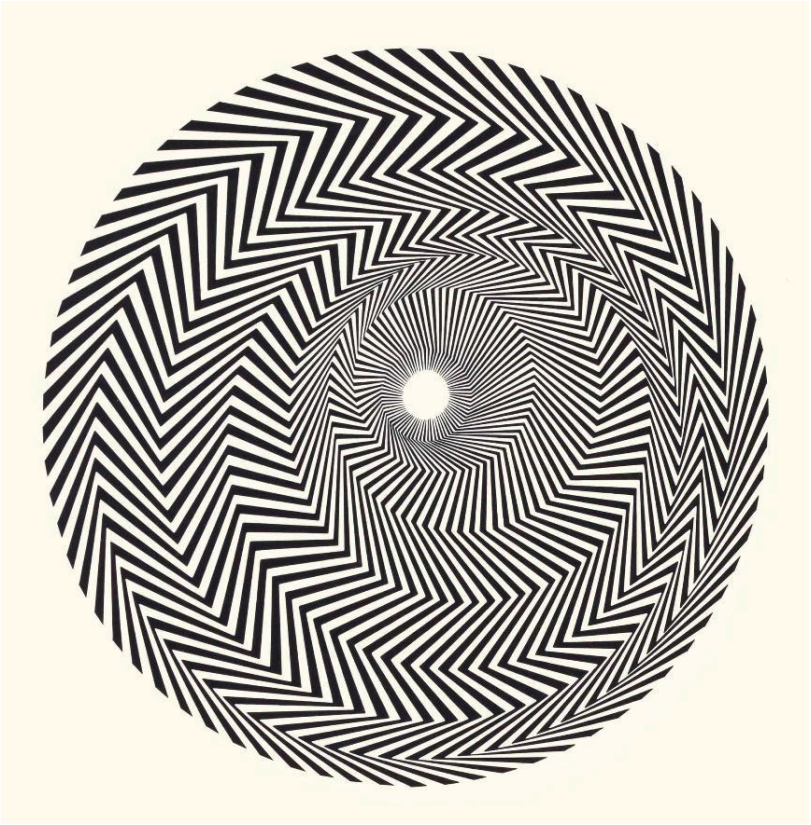

Figure 12Bridget Riley Blaze 1964, emulsion on hardboard

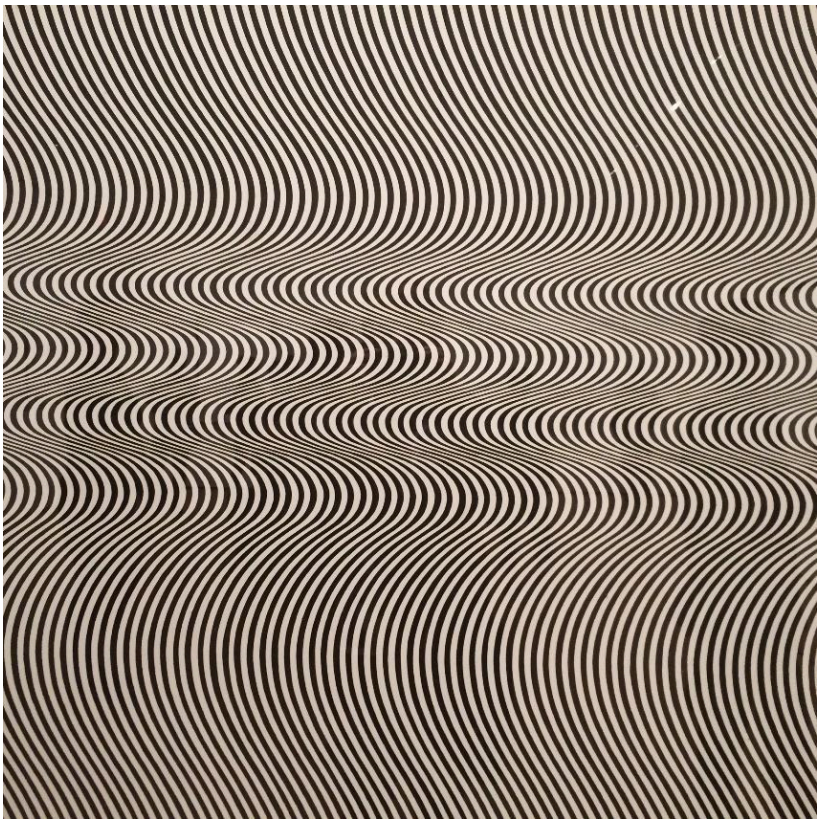

Figure 13Bridget Riley Current 1964, polymer paint on board

Bridget Riley

> *No painter, alive or dead, has ever made us more conscious of our eyes than Bridget Riley(Melville, 1971)*

The pioneering Op Art painter Bridget Riley (b. 1931) represented Britain with Phillip King at the Venice Biennale in 1986. She became the first woman and the first English painter to win the International Painting Prize at Venice. The methods she employed in her paintings to create visual illusions were revolutionary at the time (see Figures 12 and 13). Whilst studying at Goldsmiths in the early 1950's, her tutor Sam Rabin encouraged her to:

> *work methodically, to strip down visual imagery in order to uncover its structure and to develop a sense of pictorial organisation(Riley, 1999)*

Her ability to visualize a sense of constancy against inconstancy was an important aspect in her paintings, changing one aspect but fixing another, which contributed to this strong sense of a portrayal of motion. Her work is geometric and Riley is in fact more interested in the natural world for visual inspiration than anything else. Her work is completely non-representational and she begins her process with a basic shape:

> *I decided that rather than trying to create abstract forms from landscape or the human figure, I would do what Mondrian had done and start with the basic elements of form: the line, the rectangle, the plane. I found that when I distorted them they became active(Riley, 2015)*

Discussed as a painter practising art as ‘an optical science’ (Jones, 2015) and that

> *the imaginative qualities of her paintings radiate beyond that optical encounter and pass through to another dimension (Robertson, 1971)*

Riley simply describes her paintings as ‘multifocal’ but she rejects science or mathematics as inspiration. She expressed regret that a lot of her work was often misinterpreted as design and that her patterns had been appropriated as fashion textiles in the 60s, or that her paintings had been discussed in terms of science. She insisted that ‘this whole scientific thing is not true, it's got nothing to do with my paintings’ and explained that she had no interest in optics or mathematics and although she had been gifted many books about these topics she never opened them (Riley, 1992).

Victor Vasarely

Victor Vasarely (1906 - 1997) was a Hungarian painter who subsequently became known as the grandfather of Op Art (Smith, 1997).

In 1928 Alexander Bortnyik opened a graphic design school called ‘Muhely’ (meaning studio in Hungarian) that followed the principals of Bauhaus and Vasarely attended classes there for two years. In 1930 he left Hungary and moved to Paris to focus on graphic design. During this time he developed what he called ‘optical kineticism’ (Gleadell, 2003) and in 1943 he returned to painting. Vasarely’s work plays with geometric abstraction, he took inspiration from the constructivists and the painters of the Dutch De Stijl movement including the artist Mondrian. In the early 1930s Vasarely began painting groups of zebras and prisoners behind striped bars, exploring the visual pattern and contrast.

Later during the 1940s he began investigating the effects of overlapping and incomplete forms, becoming fascinated by the natural geometry he encountered on the beach. This led him to start making collages with found materials and later on paintings. In 1948, after spending the summer in France, he was inspired by the effect of the strong sunlight on groups of buildings. He began making paintings from these visual plays of light that he had witnessed on the architecture and in the environment that resembled the cubist style. He was particularly interested in the flattening and abstracting of 3D form into 2D blocks of colour through painting.

During the 1950s and 1960s, he started to make paintings that conveyed a feeling of motion (see Figures 14 and 15) which had a strong relationship with the Kinetic Art works that were being produced at the same time by artists including Alexander Calder and Lazlo Moholy-Nagy. Vasarely’s works at this time were described as having

> *compositional repetition, multiplication and gradation transforming the visual into an elaborate science of the phenomenological properties of light and space (Gruen, 1971)*

Although Vasarely was 25 years older than Riley, she remembered the profound impact seeing his work as a student had on her. The artists later showed together in 1965 in *The Responsive Eye* Exhibition at MOMA. There are strong connections between Vasarely and Riley, both of whom worked in graphics and advertising before becoming painters. They were both studious observers of nature, in particular of the sea. They disagreed over the potential of universality in art. Riley did not agree with Vasarely's theory that this could be achieved through the mass reproduction of artworks (Spalding, 1999).

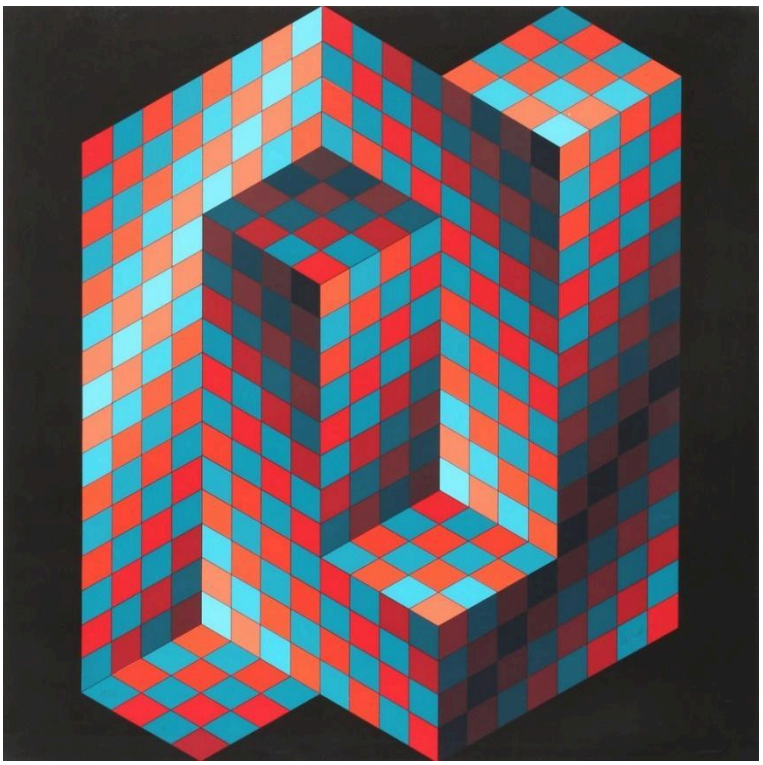

Figure 14Victor Vasarely, Gestalt 4, 1970, screenprint

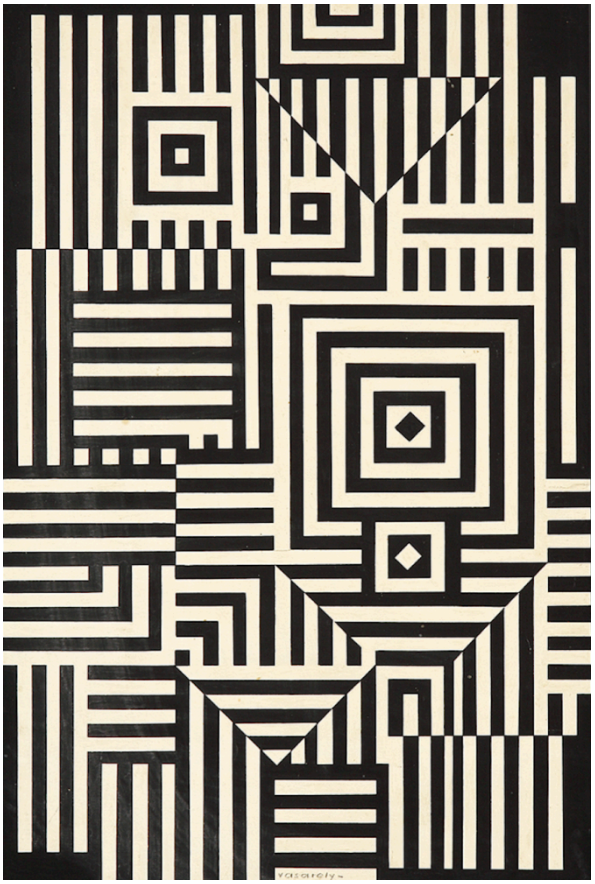

Figure 15Victor Vasarely, Riu-Kiu-C, 1960, acrylic on canvas

Expanding the Mind

The Value of Abstraction

'When the abstract art movements first came about in the western world at the beginning of the 20th century, it marked a move away from realism, a

> *recognition of the ability to appreciate form for its own sake, something that of course other cultures and fabric and wallpaper designers have long known(Latto, 2005)*

The abstract, hard edge painter and minimalist Frank Stella famously said 'What you see is what you see' (Kramer, 1967) meaning that in purely abstract work there is no reference to anything but itself. This kind of artwork showed us a new way of looking by

> *Exploring the relationships of shapes, spaces and colours to one another and this new way of representing the world profoundly challenged our expectations of art (Kandel, 2016)*

When we as viewers look at abstract, non-representational art we have the freedom to consider the relationship of parts, our own aesthetic preferences, the physicality of the materials, the interaction of the work with the space and make emotional connections that build new associations in relation to it. Abstract work contains no meaning that 'could confound simple judgements of basic sensory qualities such as depth or motion direction' (Mather, 2013, p. 155).

A minimal/abstract approach to making art can shift the focus to the viewer's aesthetic experience. The curator of the 2013 exhibition *Light Show* (see Figure 16) at The Hayward Gallery, Cliff Lauson explained that for many of the artists in the exhibition the viewer's experience and perception was paramount and

> *in order to maximise this focus on experience, many artists took a correspondingly minimal approach to their materials, producing sculptures*

and installations that are elegant, mysterious and perceptually 'light" (Lauson et al., 2013)

Similarly Melissa Feldman, curator of the 2015 exhibition *Another Minimalism: Art After California Light and Space* in The Fruitmarket Gallery in Edinburgh wrote about the aspiration of the minimal theme of the works in the show: 'to provide a perceptual and sensorial re-sensitising through direct experience' (Feldman, 2015). This way of making work avoids illusion, metaphor and overt symbolism. Minimalist works dismantle the separation between the viewer and the art; there isn't any pictorial imagery to consider or narrative concept to learn. Recently there was been a resurgence of interest in art from the 1960s. The 2017 exhibition *Kaleidoscope: Colour and Sequence in 1960s British Art* in Yorkshire Sculpture Park (see Figure 17) surveyed work from Op Art, New Generation Sculpture, Pop Art and Constructivism in Britain.

Post-minimalism lives on in artists like Richard Serra and Keith Sonnier, but the images from the *Kaleidoscope* exhibition look contemporary and current, not as though the work was made 50 years ago. The curator, Natalie Rudd comments that 50 years after this work was made 'one is struck by its continued immediacy and directness, its vibrancy, its sense of positivity about the present and future' (Rudd, 2017).

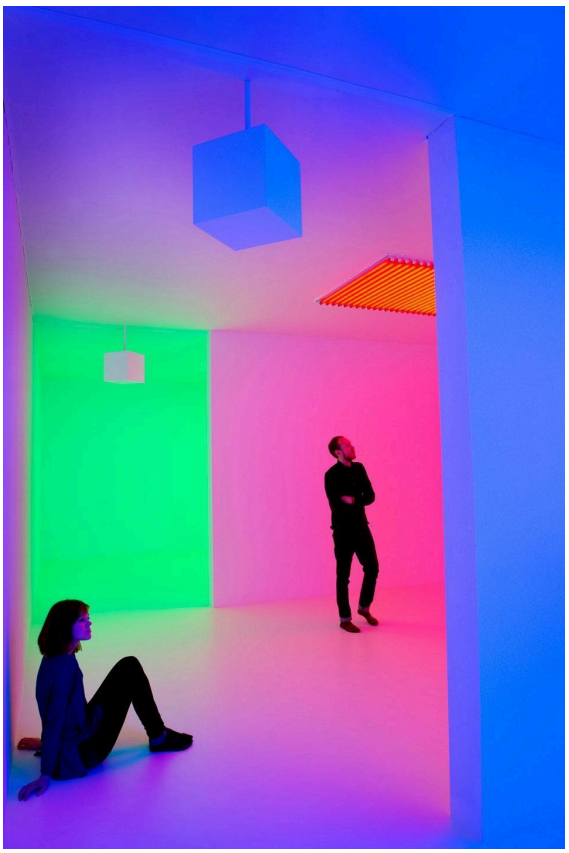

Figure 16 Carlos Cruz-Diez'sChromosaturation at Light Show

Figure 17Kaleidoscope: Colour and Sequence in 1960s British Art

Memory/Recognition

A principal of abstract art is the exclusion of representational imagery. I'm interested in what happens when we look at an abstract artwork and struggle to recognise it or understand its meaning as a whole. I think this experience is valuable and has to potential to create new neural pathways in the brain. Because art is constantly progressing and the combinations of form and colour are limitless, it is important to understand how recognition works and the value of novel stimuli to the viewer.

So what is recognition? 'Object recognition begins with the retinal image and ends with our ability to say "that's a melon" or "that's my friend Bill" (Shimamura, 2015, p. 53). When we look at something we have to compare it with everything that we've seen before. We store representations of the things that we've seen in our long-term visual memory. This comparison process only takes about a fifth of a second which, 'in itself is a remarkable feat achieved by the brain' (Mather, 2013, p. 65) When you experience something new, 'you begin by linking it with prior knowledge' (Shimamura, 2015, p. 125).

What value can the experience of not recognising something hold? Encountering the unfamiliar in visual art can be a way to heighten viewer engagement (Anya Hurlbert, 2018). Why bother trying to make representations of things in a digital age, when an image of any object can be summoned up by anyone on their smartphone instantly?

Artist Wolfgang Laib wrote: 'for me, the sky is much more important than trying to make a painting that is a symbol for the sky' (Laib, 2001) And the sculptor Tony Cragg explains his motivation for making abstract work is

> *the creation of objects that don't exist in the natural or functional world, that can reflect and transmit information and feelings about the world and my own experience' (Cragg, 2004)*

and hopes that his work forces viewers to 'deal with the unfamiliar, not the bloody dead reality they know' (Cragg, 2004).

Traditionally, artists have tried to break ‘the link between image and stored knowledge’ by drawing objects upside down or reflected in a mirror. This helps them to really see what is in front of them and not draw the stored representation that they have in their mind (Jolicoeur, 1985). By shifting the viewer’s perspective we de-familiarise the familiar which encourages us as viewers to see what we know as something new. Visual memory can also be challenged when the whole is correct but details are wrong, for example in Ron Mueck’s figures. ‘Early processes in the occipital cortex would assert “this object is huge”, while later processes in the temporal cortex would assert “no it’s a human being, it cannot be huge”’ (Mather, 2013, p. 39).

Art as a Tool for Cognitive Growth

Presenting viewers with abstract forms and unusual imagery in art encourages curiosity, which is a good tool for effective learning. When we see something new

> *an activation path is laid down in the brain that connects the sensory, conceptual and emotional processes involved(Shimamura, 2015, p. 107)*

According to a study in the journal *Neuron,* being curious about a subject can actually make the brain more receptive to remembering what one learns by activating key regions of the brain (Gruber et al., 2014). What does this mean for art? It can mean that looking at abstract art in particular is pleasurable because it

> *involves deliberate overstatement, exaggeration, and distortion designed to pique our curiosity and produce a satisfying emotional response in our brains(Ramachandan, 1999)*

and it can satisfy our natural drive for exploration and curiosity (Mather, 2013, p. 176). When the image is uncluttered and abstracted, there is room for the viewer to project their own interpretations and emotions onto the work:

> *To perceive an essential component of a work in isolation be in form, line, colour, or light. The isolated component stimulates aspects of our imagination in ways that a complex image might not (Kandel, 2016)*

Interviews

Susan Aldworth

To explore my research into the science of perception further I conducted two interviews. The first was with artist Susan Aldworth, a lecturer on the Art and Science MA course at Central St. Martins and a philosopher who works with film and print making. Her artwork considers the impact of epilepsy and schizophrenia on people who suffer from these conditions and examines their experience of losing a sense of self, something we all take for granted. She refers to this collection of experiences and consciousness as your sense of self. Her interest is in the workings of the brain: 'it's a miracle that a bodily organ can summon up a personality and that you have imagination' (Aldworth, 2018).

Anya Hurlbert

My second interview was with Anya Hurlbert, a professor of visual neuroscience at The Institute of Neuroscience at Newcastle University. Her research focuses on colour perception and she was the Science Trustee for The National Gallery from 2010-2018. We discussed modular processing – where specific visual elements are singled out in the early stages of processing, for example: edges, orientation/form, depth, position, texture and colour. The brain 'builds up a representation of a 3D scene by analysing elementary features in this modular way' (Anya Hurlbert, 2018) and parts of the brain are specialised to handle different elements 'there are clusters of neurons that are only interested in colour.' At later stages of processing the brain amalgamates this information to understand the visual scene as a whole. When we discussed the effect of experiencing the unfamiliar on your brain, Anya spoke about how increased involvement can be beneficial to the enjoyment of an artwork: 'the more work you do, the more involved you are with the work of art, the more it arouses appreciation within you because you're engaging more with it' (Anya Hurlbert, 2018). When an image is dynamic we can generate a greater number of hypothesis which makes the image more interesting to us. I asked her 'Do you think that understanding how we see and process visual information can inform the creation of visual art?' she strong supported this statement.

Conclusion

Understanding the science of visual perception is highly valuable because it will better inform the creation of art. The 2D image projected onto the retina and built up into a 3D representation of the world by the brain is fascinating to me. An understanding of modular processing and Kandel's reductionism theory feed into to my studio practice. The artists I have mentioned, sculptors Bolus and Annesley and Op painters Riley and Vasarely, are important to my practice as a sculptor because I am thoroughly interested in pattern. Op Art created perceptual visual disturbances through the creation of artificial depth in 2D pattern and the work of New Generation sculptors Bolus and Annesley takes simple stripes, shapes and pattern and applies them as a skin of paint to 3D form.

There has recently been a renewed interested in painting and sculpture from the 1960s[5]. These artists were innovators because shifting the viewer's attention from imagined pictorial space to their own physical interaction with the artwork has led to many new art movements including performance, digital art, site specific work, moving image, participatory art and more recently a whole new generation of installation artists like Jeppe Hein, Chiharu Shiota, Spencer Finch and Olafur Eliasson.

In separating out visual elements like colour, scale and line, minimalist artists were unknowingly exploiting the modular processing of the human visual system. Moreover through abstraction (novel stimuli) these artists were forcing the viewer's brain into specialised routines for processing unfamiliar perceptual input. This appears likely to be beneficial for cognitive growth. In the case of minimalism, understanding the neuroscience of perception helps us to understand why these novel forms are good for us and perhaps what is good about the art. Further research could explore whether this is true of other forms of

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[5]*Kaleidoscope: Colour and Sequence in 1960s British Art* 2017 Yorkshire Sculpture Park, *When Attitudes Become Form,* 2013, 55th Venice Biennale, *Bridget Riley,* October 2019, Hayward Gallery, *Other Primary Structures,* 2014, Jewish Museum, New York, *The New Situation: Art in London in the Sixties,* 2014, Sotheby's

visual art too. Can we find a correlation between what a viewer is looking at and the activation of corresponding groups of neurons? In the future could artists exploit the potential of this understanding and design work to manipulate modular processing and evoke a specific and likely response?

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Appendices

Appendix A - Interview with Susan Aldworth

Artist in Residence at the Institute of Neuroscience, Newcastle University

Lecturer on the Art and Science MA at Central St. Martins, London

All responses in italics

I'm interested in the overlap between science and art, I would like to ask you a few questions if you don't mind

The relationship between art and science is really interesting.. when I first started working in this area mainstream curators would have nothing to do with science because they felt it was illustration rather than fine art and I think now it's just become a bit more inclusive which is great. I hate the label art and science, I think its art. I just happen to love science as a way of getting into it.

I would love to hear about your time here at Newcastle University when you were artist in residence of the neuroscience department

Okay well there's two phases of that, I was artist in residence here from 2008 to 2012 and I'm currently artist in residence again now on a new project. There'll be a show at The Hatton Gallery in 2020, so do you want to hear about both residencies or just the first one?

Yes, both.

Well the first residency was when I was just taken on board as artist in residence. There was nothing in particular in mind. I had just done an exhibition in Sunderland called 'Scribing the Soul' about human identity and the relationship between the brain. I have a background in philosophy, and I got caught up with the neuroscience department here and they had something called Brain Week,

so I was invited to come and talk at Brain Week and then they offered me a residency. It was an open ended one with no particular focus and then after a while I talked to lots of scientists and I ended up deciding to focus on schizophrenia. What I'm really interested in is what makes me me and you you, the sense of self really. And it's a very basic thing, that we wake up every morning just feeling ourselves but it doesn't happen for everyone; if you have schizophrenia or you have dementia or you have a stroke in the night you might wake up having lost that sense of self, or if you have a big fit. I'm very interested in that sort of fragility of selfhood that feels very ordinary until something goes wrong. So, schizophrenia seemed to me particularly interesting because it's a condition of the brain that sort of steals your personality because it sort of changes who you are and no one quite knows why it happens or what's going on in the brain.

I found a group of scientists who were working on schizophrenia and I got The Hatton Gallery to agree to give me a show. One of the ways I practice is not only to embed myself in science but because I work in science that looks at the human brain I wanted to talk to people who had schizophrenia because it seemed to me my view on schizophrenia wasn't very interesting on its own. You need to embed it both in the science and in the experience of it and I found two local artists in Newcastle both with a schizophrenia diagnosis and we worked on the project together. They did their portraits of themselves as having schizophrenia and many of their portraits were about the experience both of hearing voices, seeing images, the sort of wider psychosis side of schizophrenia. My work was about trying to make the audience feel what it would be like to be slightly disembodied. So I went to the Curwen Studios in Cambridge, got an Art's Council grant and I made a series of work called Reassembling the Self, where I literally put body parts together in the wrong order and made these rather aggressive prints. I also made a film which was based on the text of someone who had schizophrenia from the 1980s. So the residency was the sort of catalyst behind the exhibition. But the exhibition itself took in much more than the science and it was trying to explore what schizophrenia really was. It was a good show, it travelled from The Hatton to London and then to Manchester and we had huge audiences. We realised schizophrenia affects many many families but nobody

really talks about it. So that's what happened there. Is there the sort of narrative you were looking for? Please ask questions if you want

I'm really interested in the sense of self thing as well because I've been looking at neuroscience and the perception of art, that we all have the same kinds of structures in our brains but our preferences are so different depending on your past experiences and I think a whole load of factors that I haven't even got to yet.

One of the first things I learned when I started working in hospitals – I got interested in this because I had collapsed in my studio 20 or 30 years ago with a suspected brain haemorrhage, it wasn't, in fact it was inhaling too many white spirits, so always ventilate your studio, but I ended up on an operating table having the sort of scan where you can see the workings of your brain while you're conscious, so it was a scan in real time. So I was looking inside my own brain and it was an epiphany really because I was literally watching myself think. It made me start thinking about the brain as an object, as a thing and, exactly what you're talking about, what is a sense of self? So there's lots of ways of looking at a sense of self. One is: what is the relationship over time? So you're that baby who was born with that brain and now you're that 60 year old woman who's still got that brain and I have a sense of continuity, but it's a biological growth of the brain, it's changed, I've changed. Every single experience that I've had has fed into this brain to make me who I am now. And when is it really me? Because today I'm different from the person I was yesterday because I've had those more experiences. So I find the changing of the brain, the plasticity, the fragility of it very very interesting. So a sense of self might be an illusion that the brain conjures up for ourselves so that we survive. It's important for us to have a sense of self because it roots us, but it isn't something you can grasp, you can't open up a brain and see a self. It's a living working thing that's embedded in the whole body. I find it deeply fascinating.

Yes it's amazing, because nobody really knows, do they?

And can a brain really understand itself? In the end can neuroscientists use a brain to understand the human brain? It's very fascinating

Yes, I've been reading about art as a product of the brain, as a way of communication and expression, to be processed by other brains. When you think about it that way it's amazing

And why should we have this facility and this enjoyment of art and aesthetics? Is it survival? Is it a mutation? We don't know why, so it's all fascinating. The whole intellect and analytical qualities, you can see why they are important for survival but they have just become so rarefied in our society.

How does your crossover into science inform your creative practice?

Both everything and nothing is the truth to that. My work doesn't illustrate science but it is certainly inspired by it. The science is one of many factors and I'm also a very technical artist so technique informs my practice very much. I have a degree in philosophy before I started fine art, so I think I also have a very sort of cerebral approach to art. Some of the methodology of science I like, I like this research process that I always go through before I start work. It often involves drawing, notetaking, going to witness what scientists are doing. It might be a good example to talk about this latest project that I'm working on with The Institute of Neuroscience which is looking at the possibility of introducing light sensitive genetic matter into a brain of someone with epilepsy, and the also implanting a small computer chip so they will be able to monitor when a fit might happen and switch it off using light. It's very early stages. So that's the science that I'm looking at so I then have to make an exhibition about it, so then I start thinking about the implication of that for people with epilepsy. Does it turn you into a sort of human hybrid if you have a jellyfish gene that's been put in your brain and that gene is a light reflective gene so it will respond to light and it's sitting in a HIV virus. I don't really quite understand it all, but it's amazing genetic engineering. So I have all that information, and I have to think what I am trying to say. I don't really want to make a piece of work that just illustrates the science, because the scientists can do that very well themselves nowadays because they have wonderful film footage of what they're doing. What I want to do is make a piece of art that questions what they're doing, introduces notions of human hybridity and also maybe opens up the experience of epilepsy to people who might not understand what it is. I had to come with a concept for this piece of work, so what

I have decided to do is embroider. Epilepsy affects one in one hundred people, so what I'm going to do is get one hundred people to embroider one hundred epilepsy stories onto pieces of clothing. The clothing will form a big kinetic installation. So that's the human testimony and clothing is old Victorian clothing which has a history in itself. It's the idea that this clothing is embodied selves, so that's what the outside is going to look like. I'm working with scientists who are going to help me program this sculpture to move with the neural pathways that happen in an epileptic fit, so they'll be motors that can move the clothes. I don't quite know what it's going to be like. What happens before you have an epileptic fit is that everything goes into synchronized movements, so that in the sculpture everything will be moving and then it will collapse into a seizure and then slowly start off again. We're also hoping to program it so that every day it's random and different so that it looks like the sculpture is a living thing because it's not being told what to do, it decides what to do itself in a way. And then sometimes when we shine a blue light on it, which is what they do in the brain when they shine the light on the jellyfish genes, that stops the fit happening. So I'm going to use science to inform the movement of the work but the aesthetic and the intention of it is my art practice. That's more closely related to science than I often do but I think that if people come and see the work they won't think it's a scientific piece of work. It will look very much like an art installation that they can respond to emotionally and they can then find out more about the piece if they want to.

What aspects of the mind interest you the most?

I think it is the sense of self and consciousness because I just think it's a miracle that a bodily organ can summon up a personality and that you have imagination. I had this experience of going to a dissection of a human brain a while ago. Do you know the work of Helen Chadwick? She died very young, she's a wonderful artist from London who died in the 1990s I think. Look up her work she's really important. She did this fantastic self-portrait that was just her holding a brain. So I went to this brain dissection and held the human brain in my hands. It was a very extraordinary moving thing and it seemed to me that this object was both subject and object and that's what really fascinates me about the brain if I'm honest, the sort of objective nature of a bodily organ but it gives us subjective experience.

One of the interesting things is that it's such a complex organ that scientists tend to have to work on tiny little bits of it. So someone might work on eyes, someone might work on epilepsy, someone might work on something else. So no one can look at the whole thing because it's so complex. So one of the things that I try to do is step back from the science to try and think about this sense of self and how fragile it is. You can have a stroke, you can have epilepsy, you can have schizophrenia, you can have dementia. It isn't something you can guarantee you'll always have in your life. It is that sense of embodiment that I find intriguing. They have now found, for instance, that there are some brain cells in your stomach. All over the body there are these strange connections. You also have an emotional life that can change your brain. You can get depressed, you can get ill because of how you are. That's what I find interesting, did I answer your question?

Yes, thank you. I was going to ask you about your creative process but you have told me a little about that..

Well my creative process.. Often drawing is a way in, I always have a notebook to draw and write in and that is my way in. Print is my specialist field because I love the alchemy of print. You never quite know, because the final thing is an image that comes through a press in reverse, you never quite know what it's going to do, so I like that. I like subvert techniques to make them work for me. I go through many, many thrown away ideas and bits of work until I find the ones I like. There's more in the bin than there is that comes out on the wall.

For me too, you have to experiment and work through them

I do think of an artist's studio a bit like a scientist's lab nowadays. I do look at it as a place of experimenting. Problem solving, but not necessarily at an intellectual stage. The research stage to me is very intellectual, but the making stage to me is more touch and feel and instinct. I listen to Radio 4 in the studio so I don't have to really think when I'm making work, I don't have to engage my full intellect, it's other stuff that comes into play. Does that resonate with you?

Yes, sometimes you're just doing the same thing with your hands again and again or you're up and down ladders.

It's interesting. So the studio is a very, very important place for my practice. And becoming more and more unaffordable for artists.

It's the same here in Newcastle

My rent in London, well I've now built a studio in my garden, like a big shed because it went from £100 a month, then £150, 200 and it was getting up to £1000 a month and I just thought I'm out. And you have no rights anymore so they can just increase it as they want, anyway..

The last question I wanted to ask was why have you chosen to make work around epilepsy specifically?

Both times it's been commissions. But again I'm interested in conditions that affect your sense of self and epilepsy does. It can cause cognitive deficits and also they are very very interesting. The grand mal, which is a big fit you can have with epilepsy, a friend of mine who has epilepsy described it to me beautifully. When you have a grand mal, you fall on the floor and you're just out of it and you fit and then you slowly start to come round. He said when you come round you slowly come back into consciousness. He can remember someone standing over him as child saying 'are you alright?' 'are you alright?' and he had a sense of familiarity and could intellectually think: that's my mum. He said that over a few days you had to put your sense of self back together. It's like a computer has wiped your sense of self and it has slowly rebooted. It's emotionally a really painful thing because you have lots of things that you don't understand or you don't know anymore. On top of that an epileptic fit is hugely painful, because your muscles have gone into spasm. So for a week afterwards you're just intellectually and physically knackered. This idea of something wiping your sense of self, that's why I'm particularly interested in epilepsy. It doesn't always happen like that but what does that mean about what the brain is really? So that's why it fascinates

I had an aunt who had epilepsy but she had other disabilities so she couldn't really express herself to tell me about it but it did seem like it was really painful. I didn't know that afterwards you might have confusion.

The other thing is that epilepsy affects one in one hundred of the population and that's a big number and nearly everybody I talk to has some epilepsy in the family somewhere, like your story. And yet, can you name any famous people who have epilepsy? It's so secret and stigmatised. And there must be hundreds who do. So that's what's really interesting. That everyone keeps it a secret. I suppose it can have this public manifestation of a fit, which is really difficult and dangerous. It can kill you if you have a fit in the wrong place, if you're up a ladder or you're in the wrong place at the wrong time. It fascinates me because it does challenge what we think of as a continual sense of self through our lives

You have to keep rebuilding it?

Yes and it will change, now you are yourself plus that fit. Anyway I think it's all quite interesting.

That's everything I wanted to ask you, thank you.

Appendix B - Interview with Anya Hurlbert

Interview with Anya Hurlbert

Professor of Visual Neuroscience at The Institute of Neuroscience, Newcastle University

Scientist Trustee at The National Gallery, London, 2010-2018

All responses in italics

I wanted to ask if you have done any research around perceptual art? I'm particularly interested in abstract work from the 1960s onward. I'll explain what I mean as perceptual work: Sol Le Witt defined it as art 'that is made for the sensation of the eye primarily, would be called perceptual rather than conceptual and this would include most optical, light and colour art'

He is talking about more modern abstract art, that's interesting. The first thing I would say is that I would slightly take exception to his definition, because I think that all art is there to delight and stimulate not just the eye, but the eye and brain. I would take so much exception with that, first of all because the sensation of the eye doesn't really make sense in that the eye receives information. It's the site of the transition of the light signal. But it's not where sensation occurs, it's certainly not where perception occurs. That takes place at higher levels in the cortex, so it's unclear what he means.

I would say that old masters are also creating something that is designed to elicit visual perception from marks on a surface. How is that different from abstract art? Just because it's representational, it's trying to elicit a world. Whether the world is in some way an explicit representation of an external reality or whether it's an internally created virtual world. I don't see that there's a clear demarcation. You could also argue that external reality is just a product of our visual system. In any case each one of us carries around our own private representation of the internal world. How do we differentiate that from the external world? What visual art does is just elicit those perceptual worlds.

I've been reading about the way the brain works and the way that it splits up visual elements for processing like colour, motion, scale, orientation. The implication of this for visual art is really interesting to me, like the way that the fauvist painters were particularly interested in colour and it has been shown that looking at futurist style paintings activates the part of your brain that processes motion. I think that's really interesting. So, strong use of colour or another element that is selective to a specific area in the brain during visual processing, I think that it can give a very direct experience and that 'visual attributes that are singled out for modular processing have primacy in visual art'. Mather wrote that, he writes a lot about the psychology of art and it is supported by Livingstone and Zeki so I was wondering if you thought there was any truth to that?

Definitely, I think this goes back to what I was saying earlier, that we vision scientists have learned a lot about how the visual system processes what we call 'visual cues', so 2 dimensional cues, in order to infer representations of the 3 dimensional world. One way to think of vision can be encapsulated as inverse optics. So optics would be taking a three dimensional scene and then

transforming it into a two dimensional image, so you think about perspective projection for example. Inverse optics is starting with that two dimensional image and trying to reconstruct the three dimensional world that created it, so that's what the visual system is doing, because it's interpreting the two dimensional images which form on the retina. What the visual system is thought to do is build up a representation of the 3d scene that created it by analysing elementary features in this modular way. Now this is one way to describe what vision does. It's very Maar-ian. It's very much the David Marr view and it informed a lot of research into what we call computational vision or developing computer systems that can see the way humans do. That was kind of the philosophy that drove a lot of artificial intelligence and research into artificial vision systems and also drove our understanding of the human visual system.

What you can start with from this pattern is to pick out edges, so regions of the image where there is a strong difference between light and dark, and enhance those edges to come up with contours which might correspond to boundaries of objects, for example, and the visual system is able to process light dark edges at different orientations. It can build up something like a black and white sketch of the scene. So I've got the line that goes round your head, shoulders and the back of the chair. And there's a hard right angle there which is the edge of the filing cabinet so I've kind of got a black and white sketch of the different surfaces in the room and so one module in the visual system is the very early module that detects light dark edges at different orientations. This would be the orientation or form module. And that's Livingstone refers to, orientation.

Depth can be worked out by comparing differences in locations of edges or other features in the image between the two eyes and then you can work out whether something is in front of or behind something else. Texture gradients on surfaces which are also generally made up of edges can tell you whether something is slanting away from you or towards you, or is far away or nearby. Colour tells you about the properties of the surface that's demarcated by those boundaries, which are created by analysing it at different orientations. Differences in the spectral properties of regions within the image tell you something about the material properties of the surfaces that exist there.

So these things can be analysed independently of each other to a certain extent and they seem to be in the sense that in the visual system there seems to be distinct functional and anatomical modules, meaning that there are clusters of neurons that are only interested in colour. That seems to be what they do, they're not really looking at edges or motion, they're not looking at changes over time, they're not comparing locations of features between the two eyes, they're not doing depth. They are only analysing spectral information which tells you something about colour and potentially material. There are columns of neurons that are responsive to different orientations of edges, so they seem to be

working independently and in a segregated way in different chunks of brain so you can talk about modular processing, it does seem to be the case. The brain is divided up in this way.

At some point it's all got to come together because we don't just see disembodied edges and surfaces and things moving without knowing what it is that's' moving, so it's got to get integrated somewhere. So the idea is that the visual system

does this in early stages, analyses the visual image in this sort of modular way and then sort of pull its together and integrates it at later or higher stages of processing. This is generally what we in the field think the brain is doing, so your question was do I agree with this? Yes, generally I do. I don't think it's a step by step hierarchy, I don't think its hierarchical processing one stage feeding in through the other, I think there's much more feedback and lateral connections and it's more of a dynamic process that takes place sequentially. It's pretty hard to simulate and it's hard to describe it in words but I'm sure you sort of feel that way because you feel like you perceive things in an instant.

I've been looking at that process of object recognition and the way the mind stores the idea of a banana or a book and then when you see it from an unfamiliar orientation you can still understand what it is because you have that stored image the object. I'm interested in that idea in relation to abstract sculpture. So I think, from my limited understanding of how the brain works, is that when you look at something abstract, your brain has to try to recognise what's going and make new connections

I think that I agree with that general outlook and would go one step further. I think that, this is also a point that others have made, that the more work you do, the more involved you are with the work of art, the more it arouses appreciation within you because you're engaging more with it. You're trying to understand what it means or within it trying to work out what the relationships between the parts are. Seeing it in slightly different ways, then understanding how those relate to other parts of it. More engagement, more involvement of your perceptual system and then memories and cognition and the other thoughts that it stimulates, that leads to greater appreciation of the art so some people think that that is what an aesthetic experience is. It's an involvement with the piece. That involvement can't happen if it's something completely trivial and predictable. The brain imposes hypotheses on visual images. That's what we're doing absolutely all the time, we're getting ambiguous 2d images on our retina and we're trying to make sense of them and connect them to each other over time and over space so that we can navigate and pick up objects and relate them to our behavioural needs or what we were doing in the past. So we naturally make hypothesis about visual images and images are more interesting to us the more hypothesis they generate.

I read this study that was about when someone opened their eyes and the scene was really dynamic that there was more glucose consumption in the brain because it was working harder.

Yeah, because there's more to do with it. I'm not sure that it has an explicit name, this kind of idea that this appreciation is driven by – what could we call it? Neural involvement with the piece? I don't think it has a name but it's out there, but that idea is out there. There is a piece by Bevel Conway which talks about consilience and I think he's trying to use that word in that way.

Do you think that understanding how we see and process visual information can inform the creation of visual art?

Yes, definitely.

Something else I've been reading and thinking about, is do you think there is a universal preferred aesthetic language and taste or preference based on your past experiences as a factor, but do you think that the way the brain works could be more important than taste when it comes to deciding what we like in visual art? Everyone has the same structures in our brains and I'm learning more about that, but they also have their own individual taste based on their own experiences.

I think that you've just articulated one of the big questions in both aesthetics and preference in general. The whole of vision science really is the universal versus the individual, and that is a big question. How much of what we see and why we see it and why we like it is universal, and how much is individual. We probably can't put numbers on it, but maybe it's 50/50. There are universal mechanisms, which means we all work kind of in the same way and like kind of the same thing, but then there are huge individual variations on top, and the individual variations can be partly cultural but partly due to each individual life experiences.

I've done a bit of work on colour preference and why people like different colours and whether there are differences between people's preferences for different colours, and my take on that is that there are. There is a sort of universal underlying pattern, but there are individual variations on that, and some of those are culturally driven and some of them are individual experience driven and as you might expect, there are debates and arguments between different camps on this question. It might be more useful just to talk about individual differences, and so I think framing things in terms of universal versus individual is more helpful and that's generally what we're doing.