

Colour in Flux: The Art and Science of Colour

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Introduction

How to define and describe colour is a fascinating activity for colour scientists, designers and artists alike, which I discovered when engaged in the process of articulating the appearance of Josef Albers' screen-printed portfolio *Interaction of Colour* (1963). The process of defining a colour is embedded in experience: a colour scientist may describe a colour in an altogether different way to an artist or a photographer.

How colour is perceived remains problematic yet absorbing. The 'difference between the physical fact and physic effect' as described by Albers and demonstrated in his portfolio, is an area of significance that still interests scientists and artists today [2]. This was also an area of enquiry that was to consume French chemist Michel Eugène Chevreul at the Gobelins Tapestry Works in Paris. Likewise for Johann Wolfgang von Goethe: when he completed his *Zur Farbenlehre* (1810) he claimed that his experiments on colour represented his most important achievement [3].

This article will introduce my creative practice. The colour and pattern in my work has evolved through the study of artists and scientists, all practitioners, who were interested in developing a deeper psychological, emotional and practical understanding of the visual system through their investigation of wavelength, pixels, paint and other materials. Working from a selection of prints at the Prints and Drawings Department at Tate Britain, London, I will refer to a range of artists and show a representative print for each, to interrogate how artists have used colour to challenge the viewer; to explain how colour is perceived when looking at an artwork; and lastly how these notions have informed my practical research in colour printing. Furthermore these artworks serve to illustrate how our visual system remains the most sophisticated, albeit unknown, processor of colour.

Assimilation and Contrast in My Print Practice

My interest in the notion of colour in flux evolved during a visit to Tate Gallery, Liverpool, in 2003. The initial artwork that motivated me to explore such phenomena was the painting *Yellow Attenuation* by Peter Sedgley. It is a work that I have repeatedly returned to, and have used as a point of reference, as it presents a range of queries, insights and optical challenges to the viewer. Furthermore it has informed my creative practice in printmaking and motivated technical research into colour digital printing.

Whilst viewing the painting by Peter Sedgley in the Tate Gallery with my father, we heartily discussed the perceptual impact of the vertical lines:

- Could we perceive red or orange?
- Was the yellow constant across the painting?

Neither of us could agree on exactly what we were looking at and how the painting could precisely be described. The gallery invigilator, curious about what we were arguing, came to join the discussion. Since then I have discovered that how we perceive colour is in a continual state of change: colour in flux. Moreover, colour is not fixed, but is suggestible and alterable; eye and brain do not work in perfect harmony but are in a state of consideration, reconfiguration and recalibration. For example, when reading in the evening, we do not notice when light levels drop, as our human visual system maintains a colour and luminosity constancy, that is, until it gets so dark that we look up in surprise and wonder, ‘who turned off the light?’

Additive and Subtractive Colour

The two primary methods by which colours can be mixed are:

1. Additive colour with prismatic light, and
2. Subtractive colour with artists’ pigments or dyes.

There is also a third used in colour printing that employs both additive and subtractive colour mixing, which is a significant area of interest for my research [4]. This method combines theories presented by Chevreul, as practically demonstrated through Jacob Christoph le Blon’s three-colour printing and used as a creative device by Sir Eduardo Paolozzi in the 1960s to create new ways of seeing colours through screen-printed colour and patterns.

Subtractive colour mixing refers to the material pigments of paint, dyes and inks that are applied to a white surface. Through the process of applying the paint, the reflected whiteness of the surface is subtracted. In contrast, additive colour mixing is a method to describe the addition of coloured lights at varying wavelengths. Where all three colour lights of the additive primaries (red, green and blue) are added or superimposed, white is the result. Red, green and blue are sometimes called one-third colours [5] or trichromatic colours [6].

Traditional half-tone or CMYK printing involves both additive and subtractive colour mixing, and requires the optical mixing of primary colour hues using different-sized dots to obtain variations in reflected colour.

Early Discoveries in Colour Mixing

During the 18th century, there occurred two important discoveries that influenced contemporary understanding of colour: Sir Isaac Newton’s experiments on spectral colour, additively (with light), which marked the beginning of colour science; and le Blon’s development of three-colour printing (subtractive process, using pigments), providing an early practical understanding of how colour could be printed. Le Blon practically demonstrated his theory through his prints, that a wide range of colours could be reproduced and printed by using just three colours.

Chevreul published his ideas on colour in the middle of the 19th century [7]. He was interested not only in the quality of the colours used to dye tapestries and carpets, but in the visual perception system. His principles were highly influential with the Impressionists, Neo-impressionists, Orphic Cubists and Fauvists, with artists such as Eugène Delacroix, Georges Seurat and Robert Delaunay. Chevreul's significance to the present research relates to his experiments, systematisation of colour, laws of colour contrast and the practical application of his findings in relation to tapestry weaving, an early method of half-toning to create optical colour mixtures.

At the beginning of Chevreul's directorship of the Gobelins Tapestry Works in Paris, he received complaints about the colour quality of the tapestries. He realised the colour of a strand of yarn was perceived differently depending on the colour of the yarn with which it was juxtaposed. This led to his investigation and extensive research into colour contrast, or what Chevreul termed as simultaneous contrast. Chevreul described three types of contrast effects: simultaneous, successive and mixed, successive contrast being defined as the effect of complementary afterimages after looking at a colour.

Chevreul wanted his work to be useful to all practitioners of colour [7]: 'I hope that many classes of artists, particularly dressmakers, decorators of all kinds, designers of patterns for textile fabrics, paper hangings, etc. will derive some benefit from consulting them.' He realised the importance for all workers in colour of the law of simultaneous contrast, of colour and the affect on its neighbour. Trained as a chemist, he was interested not only in the quality of the colours used to dye tapestries and carpets, but in the human visual perception system of the optical, neurological and physiological responses to colour.

Comparing the work undertaken by Chevreul using the juxtaposition of silk threads to obtain colour mixtures, I was struck by a visual similarity in the works being produced by the colour field painters in the 1960s and 1970s in the UK.

Optical Art-making by Artists

The colour field paintings of the 1960s and 1970s are particular examples of colour in flux, or vibrating colour, which has often been used by artists to create the impression of motion in their work. Marcel Duchamp noted how some colours dazzle or vibrate, and produced a work featuring this effect called *Coeurs Volants* or *Fluttering Hearts*. The phenomenological effect was first recognised by Sir Charles Wheatstone and Sir David Brewster in 1844.

Such vibrations are caused when the eye has to re-adjust to the differing wavelengths of colours. This sense of vibration or movement is also used by Patrick Heron, who used intensely saturated colours as in *January 1973: 6*, as if they had been poured straight from the can. Robyn Denny's colours combine olive greens, intense blues and hot pinks, working with a deliberate colour palette, whereas Bridget Riley uses achromatics to obtain a similar movement in her work, an eloquent example being *Coloured Greys III*.

Eduardo Paolozzi

The print *A Formula That Can Shatter into a Million Glass Bullets* (1967) by Eduardo Paolozzi illustrates how he used patterns and over-layering of pattern: crosses, dots, lines, diagonals, checkerboard and translucent colour in order to create secondary colours and subtle colour changes. Paolozzi experimented with many different colour versions of this image. He appropriated commercially printed dry-transfer patterns, which he used as stencils for screen

printing, which when overprinted created novel colour results. The combination of the pattern and colour are used so effectively that, when one stands at a particular distance from them, the patterns appear to merge to create a solid colour or assimilation.

Robyn Denny

In Robyn Denny's print series *Light of the World Suite* (1970), master screen printer Christopher Prater of Kelpra Studio was able to transcribe and capitalise on Denny's ideas through the application of flat, even colour, with sharp edges and clean lines. He was able to mix and print subtle tones and, through the layering process of screen printing, to use translucent layers to increase colour saturation. In order to obtain a range or palette of colours Denny used a formal colour wheel to hand mix and arrange his colours, which Prater could then adopt as reference. Denny juxtaposed colour combinations that were of equal tonal value, creating chromatic aberrations, or small vibrations in the eye to occur, and forcing the eye to make subtle focal adjustments.

Under these circumstances, colours appeared to float from the picture plane. Both Denny's and Prater's colour mixing for the project was undertaken entirely by visually comparing and matching colours in order to obtain the tonal balance and harmony.

Peter Sedgley

Sedgley investigated the effect of colour in flux through the advancing and receding of coloured rings, in a work entitled *Looking Glass No 7*. The ring is composite of four or five colours, which in some cases the same colour is over-printed to obtain a fine gradation and increase the density of colour. This print is an interesting example of the perceptual effect of receding or advancing [8]. Here the print is composed of a green and blue ring on a red background: when gazing at the green the red tends to advance whereas blue recedes and spreads away.

This forward–backward phenomenon is obtained through two perceptual effects: the occurrence of staccades on the retina and colour spreading in the periphery vision. Rossotti explains the effect of receding and advancing, as 'blues spreading and red advancing', which may be due to the detection of particular colours such as blue and yellow in our periphery vision, giving the impression of colours spreading, whereas red, which is more visible in the centre of vision, gives the impression that it is contracting' [8].

Sedgley also investigated the idea of complementary contrast. When placed in close mutual proximity, colours that are complementary (e.g. red and green) will increase the intensity of each other; in contrast when analogous colours (e.g. red and orange) are juxtaposed, the respective colours will appear duller. This can be seen in the work of other artists such as Heron and Denny. Conversely when patterns or half-tones of colours use complementary colours and are viewed at a distance, the resulting optical mixtures will appear dull and grey, as experienced in the work of Paolozzi. The impact of any piece work therefore tends to be dependent on the viewing distance.

Conclusion

Practitioners in colour have long experimented with colour phenomena and recording the psychological perspective of colour. Artists such as Peter Sedgley, Robyn Denny and Patrick Heron have applied theories on colour perception to their own paintings and prints; these could be regarded as examples that bridge the gap between biology, physics and art.

My interest evolved from a study of artworks at the Prints and Drawings Department at Tate Britain. It led me to understand the nature of the perceptual impact of colour and its forever-shifting impact on the eye. The prints of my work included in this article were based on my responses to the work by Chevreul, Albers and the colour field artists who were experimenting with colour during the 1960s and 1970s in the UK. My prints have combined a range of patterns, over-layering of blends of colour and the juxtaposition of colours to obtain different colour effects.

The research has also had a practical application that lies in the perceptual impact of colour: how artists make colour choices and how these can be used as a model for novel, more creative digital print-making. As an artist working in the field of colour science and digital printing, the research has been based on an investigation into developing alternative colour spaces for digital artists. As artists grapple with a commercial printer space (CMYK), engage in a photographic language (RGB) or a more colorimetric colour space ($L^*a^*b^*$) these are antithetical, non-intuitive methods for mixing artists' colour. My interest is the investigation into the development alternative methods for visualising on-screen colour, interface methods for mixing colour, creating bespoke colour sets, and being able to drive colour to ink-jet colour channels.

References

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