History of Colour

Georg Wilhelm Friedrich Hegel: "One must be wary of the certainty of the senses."

Course Objective: To provide knowledge on how we discuss colours and to offer the necessary vocabulary for their description.

Disciplines Covered: Heraldry, physics, history (and the influence of ideas), the arts, phenomenology, biology, psychophysics, sociology, and language.

Colour Comparison of the Painting *Early Morning* by Alexandre Jacob

To discuss colours, Michel Pastoureau categorises them into three ranks by order of importance:

Rank 1: **blue**, **red**, **yellow**, **green**, **white**, and **black**
Show the Olympic flag, illustrating how each of these colours appears on it, as they allow for the reproduction of most national flags.

Rank 2: **pink**, **violet**, **orange**, **gray**, **brown**

Rank 3: other colours

These are the only significant colours. For example, the French flag—blue, white, and red, which is the only official symbol of France—is described in the second article of the constitution with only these colour adjectives. What matters is the idea of the colour, not the specific colour. The blue can be azure or ultramarine, and the red can be carmine or vermillion; the specific colour has no importance or meaning.

In antiquity and during the Middle Ages, the main colours were white, red, and black. There was no word to define "blue" in either Greek or Latin, a situation that remains more or less the same in Japan today because the country is under american tutelage since the end of WWII.

Begin with Aristotle's colour order.

- If we compare it with today's colour order, the first thing we notice is the presence of white and black, which were considered colours.
- •At that time, a colour could not be thought of without its medium.
- Thus, matte white was not the same colour as glossy white, with a different word for each.

In Aristotle's classification, note the central position of red, which was considered complementary to both white and black.

It is thanks to Aristotle's classification that other colours were named. However, as he struggled to find a word for blue, "azur" was borrowed from Arabic and "blau" from the Germanic languages. Both roots remain present in Italian today.

During the Middle Ages, we see in the writings of priests that colour began to be substantivised.
For example, substantivisation in Sanskrit can be seen if necessary with how they started to count abstract numbers.

In this way, colour was distinguished from material, sparking a debate on whether colour is a result of matter or of light.

TRANSITION: Aristotle also influenced heraldry, allowing colours to be named.

Present the names of the colours used at the time and the way colours were represented in black and white through engraving, a method later adopted by the printing press.

In Art History, historians still use black-and-white reproductions to study a work.

Flanders Coat of Arms: A black lion on a field of gold

TRANSITION ASIDE: Among the colours in heraldry, incarnat (flesh tone) has no equivalent in engraving, yet it is an important colour, essential for a colour grader.

Incarnat belongs to the same family as carnation, which refers to skin colour.

In contemporary French, *carnation* refers to both the colour and texture of the skin. In English, it refers only to the colour of the skin, often called skin tone.

The first artist to use this pigment in painting history was Titian, who employed it to create variations and depth in skin tones.

However, the word disappeared from common vocabulary because of horticulturists; in the 18th century, through extensive hybridisation, they succeeded in creating a new colour by mixing the red rose and the white rose.

There was incarnat, but also a cooler variation. These two colours were blended and both came to be called "rose."

Painters tend to differentiate them today by referring to warm pink and cool pink.

The word *rose* found its way into most European languages: *rosa* in German, Italian, and Spanish, *ροζ* in Greek, *roze* in Danish, and *różowy* in Polish. However, in English, it became pink.

The history of the English word also relates to a flower, dating back to the 15th century.

The carnation (or clove-pink) has serrated petals. At the time, the term for serrated was *pinking*. Over time, pink became associated with the colour of this type of flower.

END OF ASIDE

RENAISSANCE - line versus touch

During the Renaissance, two great Italian cities tried to impose their custom to be the most influential, the most distinguished, the most prestigious, to impose the norms of courteous behaviour: Florence and Venice.

Milan, Ferrara, the Vatican too, but we're not interested in them.

Culture also played a role here, as it facilitated influence. Florence defended drawing in painting, while Venice defended colour. The best-known representatives of these two schools are Michelangelo and Leonardo Da Vinci.

Today, we tend to speak of line versus touch (*impasto* in Italian which also mean the texture the painter gives to the painting); the “touch” was substantiated by Georges Seurat with pointillism.

The line would be more descended from the representatives of this aesthetic quarrel of the 19th century: Delacroix defended the priority of colour while Ingres defended the line.

And being the good Frenchmen that we are, caricatures were published in the press at the time.

BUT WE WERE IN THE RENAISSANCE, NOW THE 15th CENTURY WITH PRINTING

It was with Gutenberg's printing press in 1450 that red ceased to be complementary to black and white.

It was black and white that became complementary, and as black ink was applied to white paper, this reinforced the idea that white represented colourlessness.

However, the opposition between white and red persists and can be found in the games of draughts or chess, which pit white pawns against red ones.

TRANSITION: But of the colours in the first row, we've only talked about white, red and black so far. What about the others?

Between the end of the sixteenth and the beginning of the seventeenth centuries, Rubens believed that it should be possible to reproduce all colours from basic pigments. In his studio, where painters, scientists, chemists and philosophers rubbed shoulders, they were able to establish several fundamental colours from

which it was possible to reproduce all the others. This is the first time that primary colours have been mentioned:

red, yellow, blue (azure), white and black.

But there's still one missing: green. Scientists were to bring it to the fore.

late sixteenth, early seventeenth century: Newton

A huge figure in the history of physics, thanks in particular to his Principia - The Laws of Universal Gravitation.

He was part of the analytical tradition of Natural Philosophy at the time, which had been initiated by Galileo. The analytical approach consisted in thinking that God expressed himself through mathematics and that the laws he found transcribed his word more faithfully than through language.

With his experiment in decomposing white light using a prism, Newton proposed a new order of colours that excluded black and white for the first time in the history of colours.

He defined 6 main colours: red, orange, yellow, green, blue and violet.

Optiks work finished in 1675 but published in 1704

However, Newton was a very pious man. For probably theological reasons, he introduced a seventh colour: indigo (the 7 deadly sins, the 7 days of Genesis, etc.).

Comparisons have been made with 7 musical notes. However, the Pythagorean scale does not fall right and required several temperaments to sound right (e.g. Bach's well-tempered keyboard). Considering Newton's piety and obsession with precision, music seems to be a beautiful but fortuitous match.

In the same period (1650s), Charles Alphonse du Fresnoy visited Italy to understand and objectify the way Venetian painters worked with colour. He found that, in the highlights, painters tended to use reds and yellows in the foreground, but blues and greens in the darker areas.

Following this pattern, he started talking about warm and cold colours. He didn't have much influence until the 1770s, when Joshua Reynolds, building on du Fresnoy's work, wrote that ‘the masses of light in a picture will always be of a mellow warmth’.

It seems natural to us today, but it's likely that the Venetians followed this ‘rule’ because of the pigments they had available. There were lots of bright yellow and red pigments, as opposed to blue and green.

Thus yellow and red were associated, by default, with light, while blue and green were associated with shade.

Note that people didn’t have the lightness or chroma words to describe colours, at the time.

It was later with Gérard de Lairesse that warm and cold could be associated with atmospheres.

But the real breakthrough in the comparison between warm and cold colours came in 1805 with Mary Gartside (an English painter and writer) who, using Newton's colour wheel, indicated that warm colours represented only 120º of the wheel, the rest being cold colours. For this to work, you have to consider that part of the red that turns to violet is already a little cold.

However, she had not drawn a diagram to support her point. The first to do so was Charles Hayter (an English painter) in 1813 who, in order to balance the proportion of warm colours to cold colours, redistributed the hues of the circle. To do this, he abandoned the Newtonian circle in favour of circles relating to the primary pigments in paint.

The idea of colour temperature had become something abstract, a mere figment of the imagination. He completely ignored Newton's spectrum and the scientific knowledge of his time. For artists, this vision has not changed in the last two centuries.

MOSES HARRIS

Despite Newton's fame, his model was not used as much by artists because Newton's mixture of primaries did not correspond to the mixture of pigments.

Explanations of how pigments mix.

Moses Harris, an endemologist, needed colours to describe insects and started from Newton's studies. He published his own colour wheel between 1769 and 1776, which corresponded more closely to the models already used by painters in his *Natural System of Colours*.

THEN JAMES CLERCK MAXWELL

Maxwell's main contributions were thermodynamics and electromagnetism because he liked to unify things. Quickly, in order to follow the transition, Maxwell realised that light behaves like a magnetic wave and made the link with the displacement of current, thus deducing that light is a wave that is part of electromagnetic radiation and that visible light is only a tiny part of it.

But in his youth (early twenties), Maxwell used discs to study colour (as Ptolemy and Newton had done before) and published his results at the age of 26 *EXPERIMENTS ON COLOUR AS PERCEIVED BY THE EYE*.

He was able to determine that the primary colours are vermilion red, emerald green and ultramarine blue, and to define their proportions so that their addition produces white. Y=0.21R+0.71V+0.08B

Explain how the inner and outer discs work.

His work is at the origin of the CIE 1931 chromaticity diagram with the Munsell matrices.

HOWEVER, another person also disagreed with Newton -> Goethe, who wrote the treatise on colours, which also had few repercussions within the scientific consensus because of its non-analytical approach. He did, however, form the basis of phenomenology with other proponents of Naturphilosophie: the rejection of the description of nature by mathematics alone. Goethe questioned Newton's lack of consideration for perception, rejecting the analytical approach without a clear distinction between the material nature of things and their manifestation as phenomena in the mind.

Goethe was also a poet and an artist. And in his time, Romanticism predominated. Romanticism gave rise to symbolism as an artistic movement, not the use of symbols.

[This is about « *the attempt to pinpoint the unfathomable in states of mind, to bring the unspeakable and even the invisible to the stage, more generally to give precedence to fantasy over reality and to dreams over everyday life, and finally to consecrate the idea at the expense of the material*.. » Petit Larousse illustré 2003]

And this is certainly where he disagreed with Newton : « *to pinpoint the unfathomable in states of mind* ».

He too carried out many experiments to write his treatise on colour, but given Newton's notoriety and Goethe's mathematically devoid approach. He received no recognition in the scientific sphere.

Goethe also drew a colour wheel similar to that of Moses Harris. He also went a little too far in associating personalities with colours. Today, we'd call that a rip-off.

But he had a big influence in the cultural sphere thanks to another book: Sorrows of Young Werther, in which he had his protagonist dress in blue. This had a profound influence on the second period of Romanticism, and then the cultural influence became :

- the blue hour - a time when men get together after work to enjoy themselves ;
- the origin of blue for boys and pink for girls. (tell story)

Moses Harris could see that with his colour wheel he could not represent the proportion of white or black in a colour. He failed to do so. Later, Philip Otto Runge, seeing the different colour wheels, wondered how we could represent the luminosity of a colour and proposed a three-dimensional representation to have an overall vision. He reintroduced black and white.

Ostwald is best known for his work categorising colours and representing them in 3 dimensions. Because he wanted to show the whiteness of the colours.

George Field, who was a colourist and supplier of pigment (colourman), also proposed a representation of colours, and we can clearly see the allusion to music in his work. He was also very pious and emphasised the trinity for the three primary colours.

BIOLOGY

Effect well known to find a colour complementary to fix a colour then watch to neutral colour.

Thomas Young and Herman von Helmholtz theorised that every colours can be seen with only three receptors : 1 green, 1 red and 1 blue. They said that each receptors send a signal to the brain.

Later we saw the LMS diagram with L for long wavelength (red), M for medium wavelength (green) and S for short wavelength (blue).

You can see that rods are sensible somewhere in between blue and green which explain the cooler atmosphere in dark condition.

Biologist found different structures of cones in the retina which corresponds to a center and a surround of an opposite colour. Each type of cones take part for any colour. This system is divided in two different pairs : green/red and bleu/yellow.

Cones are exciting ganged cells and the information is transmitted to the brain by the cell. This process is a part of the phenomenology to understand how human perception and understanding of colours work.

TETRA-CHROMATIC VISION ASIDE

Let’s have a small talk about women seeing more colours. Where does it come from?

You may have already seen the picture of these woman naming many more colours than a man. Does it mean she can see more colours? No. It’s just that a woman pays more attention to colours. But we still hear that women can see more colours. There’s a legend surrounding this about one more yellow cone.

The chromosome which support the gene responsible for red and green is

on the X chromosome next to the another, blue on the 7th chromosome. Women have two X chromosome and one of them is randomly deactivated.

At first, mammals weren't able to see red. But a mutation allowed some individuals to have an advantage to see fruits more easily. So they had a better chance to survive and the all population got this mutation. Most of animals had a dichromatic vision process.

The mutation in continent allowed the X chromosome to support both green and red allele. Randomly it occurs that the red and green allele collapse in one yellow. Sometimes, for female, both X chromosomes are activated.

In South-America, it happened that both X chromosome were activated with different genes: a yellow one.

A very few people remain with this mutation (4% of women) which need to have a South-America ascendance, before the European colonisation.

For cinema, it has no advantage because technologies are made for RGB process.

TRANSITION Despite its lack of popularity among scientists, some die-hards have nevertheless tried the non-analytical approach.

This approach has led to the establishment of numerous works and has seen the emergence of phenomenology and psycho-physics to describe phenomena observed in the way our brain reacts to this information.

(The functioning of the eye will be omitted).

1. GRASSMANN LAWS

work on the superposition of colours, certainly based on Maxwell's work, in order to formalise his work in accordance with the visual stimulus. He took up the principle of the RGB mixing and the idea of projecting the chromaticity diagram from a representation in space.

- To characterise colour equalisation, three variables are necessary and sufficient ;
- n an additive mixture of colour stimuli, only the trichromatic components are important, not the spectral compositions ;
- In an additive mixture of colour stimuli, if one or more components are gradually modified, the trichromatic components are gradually modified too.

2. ABNEYEFFECT

It also depends on the composition of the colours and their perceived intensity.

If two colours A and B have the same perceived lightness, as in the case of

the pair X and Y, then A+X and B+Y will have the same lightness.

3. WEBER-FECHNER-STEVENS LAW

Psychophysics, first Weber and Fechner and then Stevens showed the non-linearity of the perception of many things, including light. It was Stevens Smith who gave the name gamma to the contrast curve we know today.

4. HELMHOLTZ-KOHLRAUSCH PHENOMENON

Show the colour sample strip to demonstrate the intensity of a colour.

The chromatic luminance is the difference between the actual luminosity (value) and the perceived luminosity (lightness) of that same colour.

It is also important to understand that each colour at its maximum chroma will not have the same value.

5. BERZOLD-BRÜCKE EFFECT

Involves showing that the spectral signature of a colour changes when its luminosity is increased.

This phenomenon was rediscovered in 1976 when the CIE Lab was developed.

6. SIMULTANEOUS CONTRAST OF COLOURS de CHEVREUL

A chemist who was commissioned to solve a problem faced by dyers at the end of the 19th century: when they dyed clothes with different colours, it never looked the same as if the colour had been applied evenly to the garment.

Chevreul, after many experiments, concluded that this was normal and that there was nothing he could do about it, because the sensation of colour always depends on its environment. So he studied how colours react with each other and proposed a way of harmonising colours so that they juxtaposed well.

This story took place at the Gobelins factory, near the Paris animation school.

To come back to the animation on the screen with the transition from orange to brown, ask the question: do you know why there is no such thing as brown light?

Painters say that brown and orange are the same colour. Brown would be a darker version of orange.

Yes and no: brown is a darker version of orange, but they are not the same colour. They are two different colours that share the same hue. (Show on a colour wheel)

7. EWALD HERING's COLOUR OPPONENT PROCESS

Let's finish with Hering's process of opposing colours, who thinks about colour perception differently to take account of how it is processed by the brain.

He realised that there was no such thing as a greenish red or a yellowish blue. So he came up with the idea of creating a colour system that would enable all colours to be reproduced in a cylindrical space with 3 Cartesian coordinates: luminosity, the blue-yellow axis and the green-red axis.

This work was used as a basis for improving the Lab, which was not working. As a result of these improvements, we also changed the green-red axis to the green-magenta axis.

If you come across the word Lab in software such as Photoshop or others, you need to know that it's wrong, it's Luv or Lu'v', which are models made to correct the defects of the Lab.

Over the course of the 20th century, engineers developed many things to enable colours to be faithfully reproduced on our screens and in print. But that's not the point.

9. MUNSELL's ATLAS OF COLOURS

The second time in history that colour has been made substantive, or rather that its characteristics have been made substantive.

Munsell was a painter who got a bit fed up with his supplier never giving him the right colour when he ordered one. So he came up with the idea of classifying everything and giving codes to find the exact colour. He created an atlas in a thick book by distinguishing several characteristics of the colour: its value, its tint and its chroma. The code corresponded to each of these characteristics.

The value is what we would call luminosity in HSL. It is the gradation between black and white. The difference between the two is that value is information reflected by the pigments, whereas luminosity is the quantity of light emitted.

The hue is characterised by its spectral wavelength, which ranges from red to indigo. On a colour wheel, colours between red and indigo are completed by colours found on the purple line. These colours have no wavelength of their own, but exist because the brain interprets the combination of wavelengths.

Chroma is the pigment equivalent of saturation. It is a purity factor that shows how vivid a colour is. Whatever the pigment, it will lose purity when mixed with another colour, and particularly when mixed with its complementary colour. Saturation is an interpretation of this phenomenon to create a scale from one colour to grey.

He used OSWALT's method mentioned above, but with greater precision and a less linearity (scale was different for full purity of a colour for example), which enabled his model to be used as a basis for the 1931 CIE, while retaining Maxwell's method, which had proposed an equation.

NOTE SUR LES LOGICIELS

Nowadays, most software works in HSL or a derivative. In other words, instead of separating into red, green and blue or with the opposite colour process axis, colours are described by their hue, saturation and luminosity.

The HSL is based on the Lab (which doesn't work). Following the Lab, another model appeared, the LCH. From the LCH came the OKHSL. 'OK' because it is perceptually coherent. More often than not, the display in software is HSL because it makes it easier to see the tools and the differences. But in the software, OKHSL is used.

The most recent model came out in 2020 and is called OKLAB, which only Baselight has integrated today.

BUT ART

On the artistic side, other people continued to publish on colours, regardless of scientific advances. For example, Kandinsky with *Spiritualism in Art*, a book in which Kandinsky makes connections between colours and shapes.

Kandinsky was linked to the Bauhaus movement in Germany. The aim of this movement was to return to the fundamentals and propose a new development. And this also concerned colour.

At that time, there was unshakeable confidence in science. Scientists were making discovery after discovery, allowing us to imagine concepts that were increasingly abstract and even incomprehensible to the general public.

[Unfortunately, it was also during this period that New Age thinking began to emerge because of electromagnetic waves and quantum physics, which are intangible and beyond comprehension..]

The Bauhaus movement decided to go back to basics, as Maxwell had clearly demonstrated the effectiveness of mixing the three primary colours. They therefore chose to represent only (or almost only) the colours red, blue and yellow.

Can you see the problem?

No green! And the disappearance of white and black, which are fundamental to painting.

That's why there's no green in a Mondrian painting.

And the architect Le Corbusier, influenced by the Bauhaus, also used very little green.

There have also been experiments on human behaviour. It seems that blue softens the mind, whereas red incites violence.

Johannes Itten broke away from the Bauhaus movement following disagreements to create his own school and propose his own colour wheel. He said that his representation was an absolute truth about colours. That they have always been seen in this way and always will be. Which is the exact opposite of what this course is about.

There's also the story of Baker-Miller Pink. This colour, labelled P-618, has been recognised as a colour that temporarily reduces hostility and aggression. In the USA, for example, prison cells were painted with this colour to put inmates who were a little too tense. In fact, Alexander G. Schauss discovered that this colour had beneficial effects on the patient's mood.

Now you'll be looking at Shyamalan's Glass in a different light...

These days, we hear a lot about how colours have disappeared from our daily lives. The most common reason given by journalists is standardisation for purchase and resale. In other words, industrialisation. It's easier to sell something neutral than an object or appliance that seems eccentric.

What's more, a sober environment tends to enhance brands and their visual identity. Could we conclude that colour has been taken out of our everyday lives to encourage compulsive buying?

Perhaps not. Because there is also the influence of art, which, in its desire to get back to basics, has excluded colour. Le Corbusier, for example, mentioned earlier, wanted to work with raw materials, without adding colour (except for certain commissions).

David Batchelor, a Scottish artist, couldn't find inspiration in his studio and painted a sculpture pink. This was obvious to him because his environment was devoid of colour.

So he invented a word and published a book on the subject: chromophobia. And we find a vocabulary that does a disservice to colour: decadent, unsophisticated, vulgar.

And it echoes this quarrel between line and touch. Charles Blanc, a 19th-century art critic, said that colour was secondary in art. ‘A work must be appreciated above all for its design and its forms’, and he attributed several traits to colour:

Oriental rather than Western

Feminine rather than masculine

Infantile rather than adult

Colours are associated with hedonism, with appetites, not with serious, thoughtful considerations.

This neglect of colour was first instituted by Marcel Duchamps, who influenced the Bauhaus.

But in the wake of the pandemic, researchers are noticing a resurgence of colour in clothing and objects, as if the need for freedom were associated with the need for colour.

vocabulary reminder.

Finally, we have seen many colour models that attempt to show how colours mix. If we stick to the definition of a primary colour as ‘the smallest number of colours from which all the others can be reproduced’, then the RGB and CMYK models are the best. In terms of our perception of colours, scientifically, these two models offer the best contrast.

However, we've been immersed in a culture that makes me think it's a good idea to refer to the traditional colour wheel when it comes to creating harmonies. Because we're talking to people who have a cultural instinct but not necessarily a knowledge of colours.