Our associations with colour

Numerous studies have shown that exposure to different colours will also provoke a predictable range of quantifiable physiological responses. When we 'see red' with its associations with passion, impulsive action, aggression, heat and danger ('red-hot', 'the woman in red', stop signs, and red pencils), the pituitary gland produces adrenaline and triggers the body's 'fight or flight' response, leading to an increase in blood pressure, pulse rate, blood flow and rate of respiration. Conversely, 'cool' colours (blue and green) lower blood pressure, pulse rate, body temperature, perspiration, and promote deeper breathing, leading to a reduction of stress and anxiety. The sight of the colour blue causes the brain to release at least 11 tranquillising hormones, but when taken to extremes, can even cause depression ('feeling blue'). Purple is perceived as the most disturbing colour: complex and intimidating, it combines the passion and energy of red with the tranquillising effect of blue.

Research has shown that light and colour also have a significant influence on both health and behaviour. The condition known as Seasonal Affective Disorder (SAD) is a form of depression caused by a lack of near ultra-violet light during mid-winter (the 'February Blahs') and is treated by ensuring that the patient is exposed to full-spectrum lighting (light sources that also emit near-ultraviolet). The lack of near ultra-violet is also believed to be a major factor in the higher rates of suicide between December and March when days are shorter – especially in extreme latitudes.

In a British psychological research study into the effect of environmental colours on risk-taking behaviour[1], researchers found that subjects placed in red environments gambled more and took higher risks that those seated in blue or other 'cool-coloured' environments. According to psychologist Alexander Schauss of Washington's *American Institute of Biosocial Research*, pink has been shown to have a tranquillising effect on violent individuals. Following tests at the US Naval Prison in Seattle, 'Passive Pink' is now used in more than 1400 prisons and correctional facilities throughout the United States.

A recent study[2] has shown that colours even exert a powerful influence on the effects of different medications. In a series of placebo trials, de Craen demonstrated that participants given red, yellow and orange pills experienced a stimulating effect, while those participants given blue and green pills reported their effect to be tranquillising.

'Warm' colours encourage our appetites, attract our attention and stimulates us to action, hence the predominance of reds and yellows in fast-food restaurants.

- Red raises our metabolic rate and so is often used in the interior of busy restaurants and fast-food outlets to encourage us to eat quickly and leave, allowing the management to maximise customer turnover.
- Yellow is the most physiologically stimulating colour and is 'read' by the eye faster than other colours. (Signs that must be decoded quickly are often printed on a yellow background; yellow fog lights increase the visibility of the objects they illuminate.)
- Orange, incorporating the qualities of both red and yellow, is often used for safety garments (and in many American states, for prison uniforms).

1 Stary, Saunders and Wookey, 1985

2 de Craen, epidemiologist at the University of Amsterdam, 1996

‘Cool’ colours imply peace, rest and refreshment, and so are often used on the product labels of breath mints, toothpaste and mineral water. Cool pastel colours are also used in airports and hospitals to promote calm.

- Green, the colour of nature, is associated with fertility and growth and is often used in hospitals to relax patients and evoke an impression of health. When London’s Blackfriars Bridge was painted green, the number of attempted suicides dropped by 34%[3].
- Blue is associated with loyalty, integrity and conservatism, and so has always been a popular colour for the uniforms of workers within all professions: dark or navy blue for business executives, medium blue for police officers, and lighter (blue collar) shirts for mechanics, repairmen and service providers.

‘Neutral’ tones (in which no single colour predominates) also carry well-defined associations.

- White suggests formality and cleanliness (as in the lab coats of doctors), as well as goodness, purity and virginity (the robes worn by brides and the Pope, both of whom are supposedly free of the ‘stain’ of sin).
- Black implies the rejection of the material world as suggested by its Western associations with death and mourning as well as the vestments of priests, nuns and other orthodox groups whose members have renounced the material realm for the spiritual. Black also confers authority and blocks scepticism, and so is the traditional garb for teaching masters and the paramilitary forces of totalitarian regimes.

Industrial psychologists use our response to colours in order to influence our reactions to products as well as our behaviour within commercial and institutional interiors. Imagine finding yourself in each of the following three restaurants: the first is decorated in vibrant red, yellow and orange, the second in shades of green and earth tones, and the third in fuchsia, salmon and grey. Even without reading their menus, you would likely infer that the first is a fast food restaurant, the second serves ‘natural’ healthy foods, and the third specialises in expensive ‘nouvelle cuisine’.

In their design of national symbols, flags and icons, many western nations draw on these associations with ‘passionate’ red, ‘pure’ white and ‘true’ blue. The same associations lead us to associate blue with ‘conservative’ and ‘right-wing’ parties, and red with ‘left-wing’ parties (from Liberal to Communist). The popularity of red as a colour for sports cars reflects its associations with energy, vitality and sex, while black limousines express power and authority. The image of ‘the woman in red’ arouses our passion and energy, while a woman dressed in ‘girlish’ pink seems to combine the passion of red with the purity and virginity of white. The popularity of dark blue suits in the corporate sector draws on its associations with maturity, conservatism and a ‘dispassionate’ mind. (Can you imagine a business executive arriving at the office wearing a suit of bright red, yellow or orange?)

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3 Scripps Howard News Service, 01 February, 2002

How we see colour

The wavelengths we can see are just a very small portion of the electromagnetic spectrum. All forms of energy are a part of this spectrum: from radio signals whose waves can be up to hundreds of metres long – to gamma rays whose waves are measured in billionths of a millimetre. The small fraction of the electromagnetic spectrum to which our eyes are sensitive is measured in nanometres (nm) [4] and ranges from 700nm (red) to 400nm (blue). Figure 4 shows the portion of the electromagnetic spectrum visible to humans.

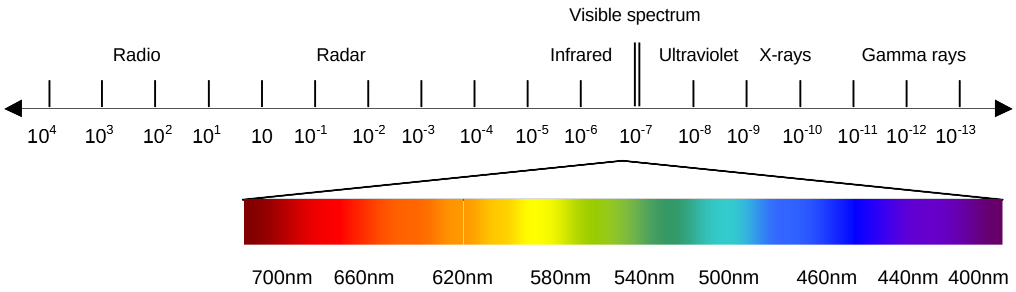

Fig. 4 The electromagnetic spectrum with the visible portion expanded

Our ability to perceive light and colour is due to the structure of the retina (the concave ‘projection screen’ at the back of the eye on which the lens of the eye focuses the rays of light) and the more than 125 million light-sensitive receptors with which it is covered. Called ‘cones’ and ‘rods’ because of their shape, these light-sensitive receptors react to light and send impulses to the primary visual cortex: an area in the brain the size of a postage stamp. Cones are capable of perceiving colours, but require a high level of illumination. Rods are more light sensitive (are able to ‘see’ in lower levels of light) than cones but are unable to distinguish between different colours[5]. At night, or in a dimly lit room, we ‘see’ with our rods, but as a result, we can only see shades of grey. We may *think* we can discern the colours of objects, but we are more likely relying on our *memory* of their colour.

Our capacity to perceive colours is due to the existence of three types of cones, each one of which is sensitive to only a portion of the visible spectrum[6]. In other words, we can only ‘see’ three colours: red, green and blue. This is why these three are referred to as the ‘primary’ colours of light, and why a colour television set with diodes of only these three colours is capable of reproducing all the colours of the rainbow. All other colours we see are the combination of two of these primary colours. For example, an object that we perceived as ‘yellow’ is reflecting equal amounts of red and green. When all three types of cones are simultaneously stimulated (in other words, when an object reflects equal amounts of all three colours at a high intensity), we perceive the object as ‘white’. When an object reflects no light at all (or if it reflects wavelengths beyond our visible spectrum) we perceive it as ‘black’.

4 1 nanometre = 10^{-9} metre. The nanometre was formerly the millimicron (mµ).

5 To use a photographic analogy, cones can be compared to 100 ISO colour film and rods to 400 ISO b&w

6 The widely accepted Young-Helmholtz theory of colour vision

As indicated in Figure 5, one type of cone responds only to wavelengths of 700 to 500nm (from red to green), a second to wavelengths of 630 to 450nm (from orange to green), and a third to wavelengths of 500 to 400nm (blue to violet). Note that the wavelengths corresponding to the colours orange, yellow and green are perceptible by two groups of cones, but that the wavelengths of blue and violet are perceptible by only one.

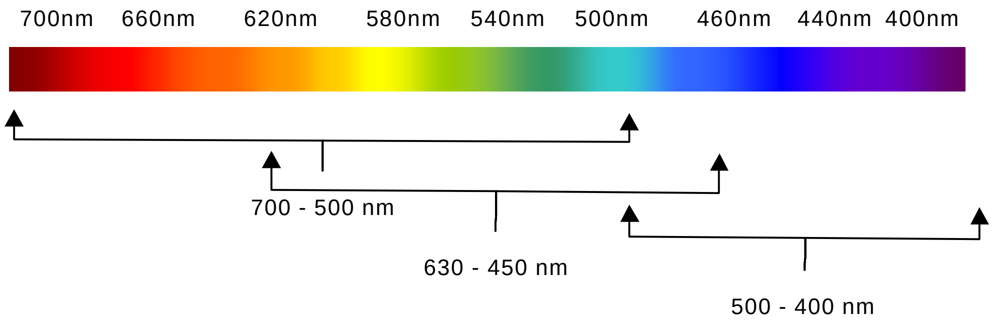

Fig. 5 The range of wavelengths perceptible to the three types of cones (from Jacobson)

The receptors of some animals are sensitive to wavelengths invisible to humans. Bees and butterflies are both capable of seeing wavelengths shorter than 400nm., into the area we call the ‘ultraviolet’ portion of the spectrum. Cats are excellent night hunters because their eyes are capable of seeing wavelengths longer than 700nm., the ‘infrared’. (This is the origin of the belief that ‘cats can see in the dark’. In a room illuminated with a deep blue light, the situation is reversed: we can see, but a cat cannot.) Of course, no animal can ‘see’ unless there is a wavelength of radiation to which its receptors are sensitive; ‘darkness’ means only that the receptors on the retina are not sensitive to the wavelengths of the ambient radiation.

The variety and sensitivity of the receptors on the retina is also at the root of the commonly held misconception that “animals see only in black and white”. The eyes of many mammals are not sensitive to the shorter (blue) rays and are only capable of seeing the longer (red) wavelengths of the spectrum. As a result, most mammals perceive objects as either ‘light’ or ‘dark’ depending solely on the quantity of red (or red-green) light the object reflects or emits. It would therefore be more accurate to say that most mammals see only in black and *red*.

Fig. 6 The world as seen by lower mammals

Maddened by the pain of the spears in his flesh, the bull is reacting to the *motion* of the matador's cape – not its colour. We can approximate the visual experience of the bull by looking at objects through a deep red filter that 'filters out' all light except red. Seen through a red filter, red and yellow objects will appear as 'light' when seen against a 'dark' background of blue or green which do not reflect red light.

The human eye does not see all colours with equal brightness. As indicated in Figure 7, our sensitivity to red and green is 10 to 15 times greater than our sensitivity to blue. (Note that the only area of the visible spectrum where the relative luminosity rises above 50% corresponds to the range of wavelengths perceptible by red- and green-sensitive cones.)

This difference in our perception of the brightness of different colours also explain why, when compared side by side with objects of red, orange, yellow or green, blue objects of the same luminosity appear to be significantly darker and why yellow objects (reflecting a portion of the visible spectrum to which two of the three types of cones are sensitive) always appear to be 'lighter' than blue objects of equal luminosity.

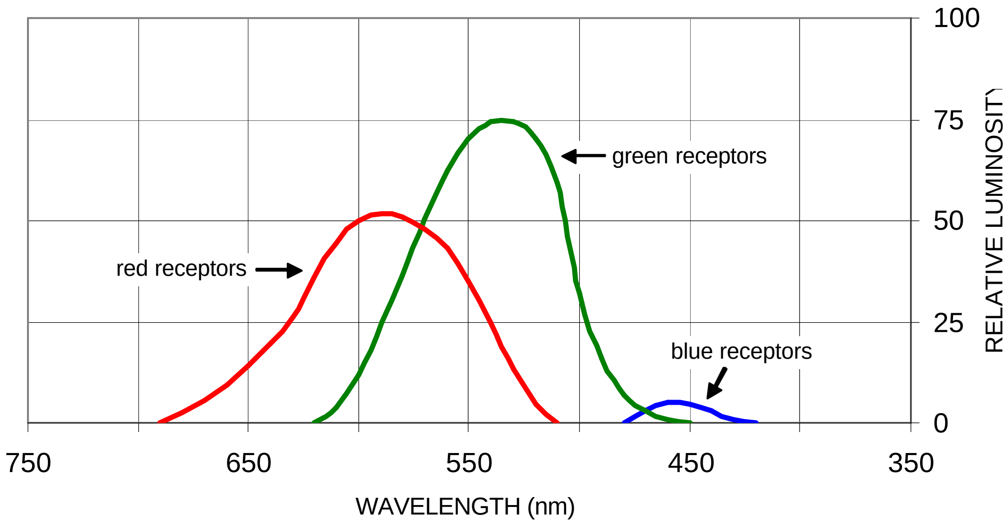

Fig. 7 The three sensation curves of the trichromatic theory of colour vision (from Jacobson)

The evolution of human colour vision

Both the nature and origin of our reactions to colours are the result of the way our eyes and brain respond to the visible spectrum. As with the symbols and archetypal images embedded within the Collective Unconscious, our associations with – as well as our emotional responses to – the colours of the visible spectrum are the legacy of our evolutionary development.

In his monumental study of the evolution of consciousness, *Cosmic Consciousness* (1901), Bucke noted that certain mental faculties (such as mankind's moral nature and musical sense) appear later in the individual and are often poorly developed or even absent (Figure 8). Bucke argued that the age of appearance of various mental faculties and that the relative ease with which a faculty can be lost is an indication of the order in which these faculties were acquired in the continuum of human mental evolution.

Faculty	Time of Appearance	Average age at which faculty now appears	Missing in what proportion of normal adults?	Circumstances in which Faculty is lost
Memory	Pre-human	Few days after birth	none	only in deep sleep and coma
Simple Consciousness	Pre-human	Few days after birth	none	only in deep sleep and coma
Curiosity	Pre-human	Ten weeks	none	only in deep sleep and coma
Use of Tools	Pre-human	Twelve months	none	only in deep sleep and coma
Shame	Pre-human	Fifteen months	none	only in deep sleep and coma
Sense of the Ludicrous	Pre-human	Fifteen months	none	only in deep sleep and coma
Self Consciousness	300 000 years ago	Three years	1 in 1 000	in deep sleep, delirium, coma and mania
Colour Sense	30 000 to 40 000 years ago	Four years	1 in 47	only occasionally present in dreams
Sense of Fragrance	Unknown	Five years	unknown	not present in dreams
Moral Nature	10 000 years ago	Fifteen years	1 in 20 or 25	Easily lost in times of stress, rare in dreams
Musical Sense	Less than 5 000 years ago	Eighteen years	More than half	Rare in dreams – even those of musicians

Fig. 8 The stability of human faculties (from Bucke)

Drawing a parallel between the appearance of these other abilities and our comparatively low sensitivity to blue (Figure 7), Bucke and others have suggested that our ability to see blue is a relatively recent evolutionary acquisition.

Based on the evidence of philology and on the testament of ancient writings, British classicist and statesman William Gladstone (1858) argued that human colour vision had evidently evolved since antiquity. Following Gladstone, naturalist Lazarus Geiger (1880) claimed that mankind's capacity to see colours had developed only gradually – and in the same order that they appear in the spectrum, starting with the longest wavelengths. Figure 9 shows the order in which Bucke proposed that the colours of the spectrum became visible to man – from longest (red) to shortest (blue). As the combination of all visible colours, note that the position of white corresponds to our development of the capacity to perceive blue.

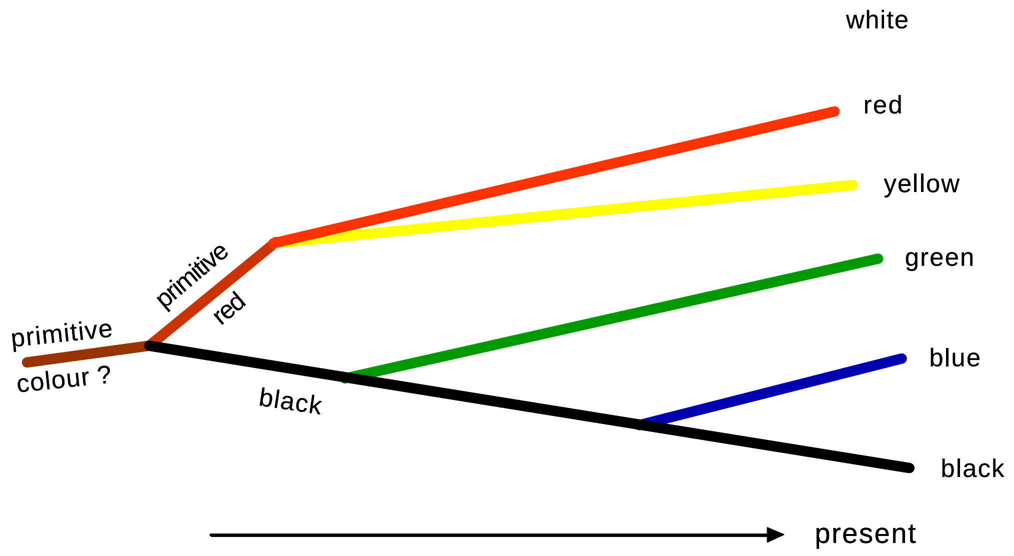

Fig. 9 The evolution of human colour vision (adapted from Bucke)

Geiger demonstrated through etymology that, as recently as fifteen or twenty thousand years ago, man was apparently conscious of only one colour; that he did not distinguish any difference between the blue of the sky, the green of the trees and the grass, the brown or grey of the soil, and the gold or purple of the clouds at sunrise or sunset. Pictet (1877) found no words for colours in primitive Indo-European speech and Mueller (1887) found no Sanskrit root whose meaning contains any reference to colour. Roman writers and historians Cicero, Pliny, and Quintilian all noted that, down to the time of Alexander, Greek painters employed only four colours: black, white, red, and yellow. According to Mueller:

> [T]he distinction of colour is of late date, that Xenophanes knew of three colours of the rainbow only – purple, red and yellow; that even Aristotle spoke of the tricoloured rainbow; and that Democritus knew of no more than four colours – black, white, red and yellow.

Bucke (1901) found that ancient texts as geographically diverse as the Rig-Veda of India, the poems of Homer, and the Bible contain not a single reference to the colour of the sky:

> At the time that the bulk of the Rig-Veda was composed, red, yellow and black were recognised as three separate shades, but these three included all colours that man at that age was capable of appreciating. [T]hroughout the Rig-Veda, the Zend-Avesta, the Homeric poems and the Bible, the colour of the sky is not once mentioned, therefore, apparently, was not recognised. … [T]he omission can hardly be attributed to accident; the ten thousand lines of the Rig-Veda are largely occupied with descriptions of the sky and all its features: the sun, moon, stars, clouds, lightening, sunrise and sunset are mentioned hundreds of times […] the writers […] could hardly have omitted by chance all mention of the blue sky. In the Bible, the sky and heaven are mentioned more than four hundred and thirty times, but still no mention is made of the colour of the former.
>
> In no part of the world is the blue of the sky more intense than in Greece and Asia Minor, where the Homeric poems were composed. Is it possible to conceive that a poet (or the poets) who saw this as we see it now could write the forty-eight long books of the Iliad and Odyssey and never once mention or refer to it? But were it possible to believe that all the poets of the Rig-Veda, Zend Avesta, Iliad, Odyssey and the Bible could have omitted the mention of the blue colour of the sky by mere accident, etymology would step in and assure us that four thousand years ago, or

> perhaps, three, blue was unknown, for at that time the subsequent names for blue were all merged in the names for black.
>
> The English word *blue* and the German word *blau* descend from a word that meant *black*. The Chinese *hi-u-an*, which now means sky-blue, formerly meant *black*. The word *nil*, which now in Persian and Arabic means blue, is derived from the name *Nile*, that is, the *black river*, of which the Latin word *Niger* is a form.

According to Bortin (2002):

> [O]ld Japanese had only four words for colour: white, red (deriving from “bright”), black (from “dark”) and blue (everything else).

On the same subject, Visser (1993) writes:

> Until the discovery of the visible spectrum in the 17th century, all other colours were considered variations of either black (brown, blue, green, violet) or white (yellow). Our colour range was therefore black – red – white. Red included orange, pink, copper and (often) gold – hence ‘Red’ Indian, and ‘not a red cent’. In several tongues, ‘coloured’ means ‘red’, like *Colorado* in Spanish.

In their study of 98 languages from a variety of linguistic families, Berlin and Kay (1969), found that seven ‘rules’ apply to the capacity of all languages to describe and distinguish colours:

1. All languages have words for white and black
2. Languages with three words for colours will include a term for red
3. Languages with four words for colours will have a word for *either* green or yellow – but not both
4. Languages with five words for colours will have words for both green and yellow
5. Languages with six words for colours will have a word for blue
6. Languages with seven words for colours will have a word for brown
7. Languages with eight or more words for colours will have a word for purple, pink, orange, grey, or some combination of these

If our sensitivity to ever-shorter wavelengths continues to evolve, our descendants may one day be able to see colours in the ultraviolet that today we (literally) cannot imagine.

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