

# The Science of Colour

*Perception, Culture, and the Politics of What We See*

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## C1 Level Reading Material

Fleydo English School

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### Chapter I: Light and the Eye

*How the brain constructs colour from electromagnetic radiation*

Colour does not exist in the physical world. This statement, however counterintuitive, is one of the most fundamental insights of modern neuroscience. What exists in the physical world is **electromagnetic radiation** — energy travelling in waves at the speed of light across a vast **spectrum** ranging from radio waves (with **wavelengths** measured in metres) to gamma rays (wavelengths smaller than an atom). The narrow band that the human visual system can detect — roughly 380 to 700 nanometres — we call "**visible light**." But the experience of colour — the redness of a rose, the blueness of a summer sky — is not a property of the light itself but a construction of the brain.

The process begins in the **retina**, the light-sensitive tissue lining the back of the eye. The retina contains two types of photoreceptor cells: **rods**, which detect brightness and are essential for vision in low light, and **cones**, which detect colour. Humans possess three types of cones, each sensitive to a different range of wavelengths: short (blue), medium (green), and long (red). This three-receptor architecture — the basis of the **trichromatic** theory of colour vision, first proposed by Thomas Young in 1802 and later refined by Hermann von Helmholtz — means that every colour we perceive is generated by the brain from the combined signals of just three types of sensor.

The **opponent process** theory, developed by Ewald Hering in the 19th century and now understood to operate at a later stage of visual **processing**, proposes that colour **perception** is organised into three opposing pairs: red versus green, blue versus yellow, and black versus white. This explains phenomena that trichromatic theory alone cannot account for — such as why we never perceive a "reddish green" or a "yellowish blue," and why staring at a red patch and then looking at a white surface produces a green afterimage.

The critical point is that colour is not "out there" in the world but is constructed by the **neural** machinery of the visual **cortex**. The same wavelength of light can appear dramatically different depending on the surrounding colours, the illumination conditions, and the viewer's prior experience — a phenomenon known as **colour constancy**. The viral "dress" photograph of 2015, in

which millions of people genuinely disagreed about whether a garment was blue-and-black or white-and-gold, provided a vivid popular demonstration of this constructive process.



## Chapter II: The Language of Colour

*Why the ancient Greeks had no word for blue — and what that tells us about the mind*

In Homer's *Iliad* and *Odyssey*, the sea is described as "wine-dark," honey is "green," sheep are "violet," and the sky is never once called blue. The 19th-century British statesman William Gladstone, a passionate classicist, was so struck by the apparent absence of blue from Homer's colour **lexicon** that he concluded the ancient Greeks must have been partially colour-blind. He was wrong — but the phenomenon he identified launched one of the most fascinating and enduring debates in the cognitive sciences: the relationship between language and perception.

The anthropologists Brent Berlin and Paul Kay's landmark 1969 study *Basic Colour Terms* proposed that all languages develop colour vocabulary in a predictable sequence. Languages with only two **basic colour terms** always distinguish black and white (or dark and light). If a third term exists, it is always red. Then yellow and green emerge (in either order), followed by blue, then brown, and finally purple, pink, orange, and grey. This **universal** hierarchy suggested that colour naming is not arbitrary but is constrained by the biology of human vision.

Yet the strong version of the **Sapir-Whorf hypothesis** — the claim that language determines thought, known as **linguistic relativity** — finds compelling support in colour research. Russian, for instance, has no single word for "blue"; instead, speakers are obliged to distinguish between **siniy** (dark blue) and **goluboy** (light blue) as separate **categories**. Experiments have shown that Russian speakers are measurably faster at discriminating between shades that cross the siniy/goluboy boundary than between equidistant shades within a single category — a performance advantage that disappears when participants are given a simultaneous verbal task, suggesting that language is actively involved in the perceptual process.

The Himba people of northern Namibia, whose language has no dedicated term for blue but multiple terms for different shades of green, demonstrate a complementary pattern: they can distinguish between greens that English speakers find identical, while struggling with the blue-green **distinction** that English speakers make effortlessly. These findings suggest that language does not determine what we can see but profoundly influences what we notice, remember, and categorise — shaping **cognition** at the boundary between perception and thought.



## Chapter III: Colour as Weapon

*From imperial purple to corporate logos — the strategic deployment of hue*

Colour has been a tool of power for as long as power has existed. Tyrian purple — a **dye** extracted from the mucus of predatory sea snails at a cost of thousands of shells per gram — was so expensive in the ancient world that its use was restricted by law to Roman emperors and senators. The **association** between purple and royalty, established over two millennia ago, persists in Western culture to this day — a striking example of how colour **symbolism**, once established, can outlast the material conditions that created it.

In the modern commercial landscape, colour is deployed with surgical precision. Corporate **branding** experts understand that colour accounts for up to 90 percent of a consumer's initial assessment of a product, and that consistent colour usage increases brand recognition by approximately 80 percent. The specific **connotations** of individual colours — red for urgency and appetite (Coca-Cola, McDonald's), blue for trust and stability (Facebook, IBM, most banks), green for health and nature (Whole Foods, Starbucks) — are carefully calibrated to trigger **subliminal** emotional responses.

Political colour **symbolism** is equally strategic. Red and blue have become so deeply entrenched in American political **identity** — Republican red, Democratic blue — that many Americans assume this coding has ancient roots. In fact, it was only standardised after the 2000 presidential election; before then, television networks alternated colours between parties from election to election. The speed with which this arbitrary coding became naturalised illustrates the power of colour to create and reinforce group identity.

Urban environments, too, are shaped by colour in ways that profoundly affect human behaviour and well-being. Research has shown that blue lighting in public spaces can reduce crime and suicide rates; that warm-coloured walls in hospital rooms accelerate patient recovery; and that the colour of school classrooms measurably affects student attention and performance. Colour, in this analysis, is not merely aesthetic decoration but an active force shaping human psychology — a tool that can be wielded for healing or for **manipulation**.



## Chapter IV: When Senses Collide

*Synaesthesia, cross-modal perception, and what colour sounds like*

**Synaesthesia** — a **neurological** condition in which stimulation of one sense automatically triggers an experience in another — offers a fascinating window into the constructive nature of perception. The most common form, grapheme-colour synaesthesia, causes letters and numbers to be perceived as inherently coloured: the letter "A" might always appear red, the number "5" always green, with a consistency and **involuntary** quality that distinguishes it from mere imagination or association.

**Chromesthesia** — sound-to-colour synaesthesia — is particularly striking. For chromesthetes, music is not merely heard but seen: each note, chord, or timbre produces a specific colour or pattern of colours in the visual field. The composer Olivier Messiaen, the painter Wassily Kandinsky, and the novelist Vladimir Nabokov all reported forms of synaesthesia that profoundly influenced their creative work. Nabokov described his experience in exquisite detail: the letter "a" was for him "the tint of weathered wood," while "s" was "a curious mixture of azure and mother-of-pearl."

Neuroscientific research suggests that synaesthesia results from atypical **cross-modal** connectivity in the brain — either through additional neural connections between sensory areas or through reduced inhibition of connections that exist in all brains but are normally suppressed. This implies that the boundaries between our senses are far less rigid than everyday experience suggests; in a sense, all perception is synaesthetic, with the brain constantly integrating information across sensory modalities to construct a unified experience of the world.



## Chapter V: Does Colour Exist?

*Qualia, the inverted spectrum, and the philosophy of subjective experience*

The science of colour ultimately leads to one of the deepest questions in philosophy: the problem of **qualia** — the **subjective** qualities of conscious experience. When you see red, you have a specific inner experience — a "what it is like" to see red — that is entirely private and, in principle, incommunicable. You can describe the wavelength of light, the neural firing patterns, the verbal label "red" — but none of these captures the felt quality of redness itself.

The philosopher John Locke posed the **inverted spectrum** thought experiment in 1690: what if your experience of red is identical to my experience of green, and vice versa, but we have both learned to apply the same word "red" to the same objects? We would never discover the discrepancy, because our behaviour would be identical. This thought experiment suggests that the **subjective experience** of colour may be fundamentally inaccessible to external observation — a conclusion that poses a profound challenge to any purely materialist account of **consciousness**.

Cultural **constructionism** offers a complementary perspective: colour categories are not simply read off the physical world but are actively constructed by the interaction of biology, language, and culture. The physical spectrum is continuous — there are no boundaries in nature between "red" and "orange" — yet we experience it as consisting of discrete categories because our brains, shaped by language and cultural practice, impose boundaries where none exist. Colour, in this view, is neither purely objective (a property of light) nor purely subjective (a creation of the mind) but something in between — an emergent property of the dynamic interaction between world, body, and culture.

The science of colour thus returns us to a question that is at once scientific and deeply personal: what is the relationship between the world as it exists and the world as we experience it? The answer, as colour research makes vividly clear, is that these are not the same thing. The world we inhabit is not the world as it is but the world as our brains construct it — filtered through the narrow bandwidth of our senses, shaped by the categories of our language, and coloured, in the most literal sense, by the machinery of our minds.

## Vocabulary Reference

Term	Definition
<b>Electromagnetic Spectrum</b>	The full range of electromagnetic radiation from radio waves to gamma rays
<b>Wavelength</b>	The distance between successive peaks of a wave
<b>Visible Light</b>	The narrow band of the spectrum detectable by the human eye
<b>Retina</b>	Light-sensitive tissue lining the back of the eye
<b>Cone</b>	Photoreceptor cell in the retina that detects colour
<b>Rod</b>	Photoreceptor cell detecting brightness; essential for low-light vision
<b>Trichromatic</b>	Based on three types of colour receptors (red, green, blue cones)
<b>Opponent Process</b>	Colour perception organised in opposing pairs: red/green, blue/yellow
<b>Perception</b>	The brain's process of interpreting sensory information
<b>Colour Constancy</b>	Perceiving object colours as stable despite changes in illumination
<b>Hue</b>	The attribute of colour defined by its dominant wavelength
<b>Saturation</b>	The intensity or purity of a colour
<b>Pigment</b>	A substance that absorbs certain wavelengths, producing visible colour
<b>Linguistic Relativity</b>	The hypothesis that language influences thought and perception
<b>Sapir-Whorf Hypothesis</b>	The theory that language structure shapes its speakers' worldview
<b>Lexicon</b>	The total vocabulary of a language or subject
<b>Categorisation</b>	The process of sorting items into groups or classes
<b>Basic Colour Term</b>	A fundamental colour word in a language (e.g. red, blue, green)
<b>Cognition</b>	The mental processes of acquiring knowledge through thought and experience
<b>Branding</b>	Creating a distinctive identity for a product or organisation
<b>Connotation</b>	An idea or feeling invoked by a word beyond its literal meaning
<b>Symbolism</b>	The use of symbols to represent ideas or qualities
<b>Subliminal</b>	Below the threshold of conscious awareness
<b>Synaesthesia</b>	A neurological condition where one sense triggers another
<b>Chromesthesia</b>	Sound-to-colour synaesthesia; seeing colours when hearing music
<b>Cross-Modal</b>	Involving interaction between different sensory modalities
<b>Involuntary</b>	Occurring without conscious control or intention
<b>Qualia</b>	The subjective, felt qualities of conscious experience

<b>Subjective Experience</b>	The private, inner quality of how something feels to an individual
<b>Consciousness</b>	The state of being aware of one's own existence and surroundings
<b>Inverted Spectrum</b>	A thought experiment about whether colour experience could differ between people
<b>Constructionism</b>	The view that knowledge and perception are actively constructed, not passively received
<b>Phenomenology</b>	The philosophical study of structures of experience and consciousness

## Fill-in-the-Blank Exercise

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**Word Bank:** *trichromatic, colour constancy, linguistic relativity, basic colour terms, branding, subliminal, synaesthesia, chromesthesia, qualia, inverted spectrum*

1. The \_\_\_\_\_ theory explains colour vision through three types of cone cells.
2. \_\_\_\_\_ allows us to perceive object colours as stable despite changing illumination.
3. The Sapir-Whorf hypothesis, also called \_\_\_\_\_, proposes that language shapes perception.
4. Berlin and Kay found that all languages develop \_\_\_\_\_ in a predictable universal sequence.
5. Corporate \_\_\_\_\_ experts know that colour accounts for up to 90% of initial product assessment.
6. Colour in advertising triggers \_\_\_\_\_ emotional responses below conscious awareness.
7. \_\_\_\_\_ is a neurological condition where stimulation of one sense triggers experience in another.
8. \_\_\_\_\_ specifically refers to sound-to-colour synaesthesia — seeing colours when hearing music.
9. The philosophical term \_\_\_\_\_ refers to the subjective, felt qualities of conscious experience.
10. Locke's \_\_\_\_\_ thought experiment asks whether your experience of red could be my experience of green.

**Answers:** 1. trichromatic 2. Colour constancy 3. linguistic relativity 4. basic colour terms 5. branding 6. subliminal 7. Synaesthesia 8. Chromesthesia 9. qualia 10. inverted spectrum

## Comprehension Quiz

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1. According to the text, colour is:

- A) A property of light waves
- B) A construction of the brain from electromagnetic signals**
- C) Identical across all species
- D) Only perceived by humans

2. The human eye has three types of cones sensitive to:

- A) Red, yellow, and blue
- B) Short (blue), medium (green), and long (red) wavelengths**
- C) Ultraviolet, visible, and infrared
- D) Warm and cool colours only

3. Homer described the sea as 'wine-dark' because:

- A) The ancient Greeks were colour-blind
- B) Ancient Greek lacked a dedicated word for blue**
- C) The Mediterranean is actually purple
- D) Homer was a poor writer

4. Berlin and Kay's research showed that:

- A) Colour naming is completely arbitrary
- B) Languages develop colour terms in a predictable universal sequence**
- C) All languages have identical colour vocabularies
- D) Colour perception is the same across all cultures

5. Russian speakers distinguish between siniy and goluboy, which demonstrates:

- A) That Russian has more words than English
- B) That language can influence the speed and accuracy of colour discrimination**
- C) That Russians see more colours
- D) That English is deficient

6. Tyrian purple's association with royalty originated from:

- A) Its calming psychological effect
- B) Its extreme cost and legal restriction to emperors**
- C) A religious decree
- D) Its abundance in nature

7. The 2015 'dress' photograph went viral because it demonstrated:

- A) Camera technology is unreliable
- B) Colour constancy — the brain constructs colour based on assumed illumination**
- C) People are dishonest about what they see
- D) Social media distorts images

8. Synaesthesia is best described as:

A) A mental illness

**B) An involuntary neurological condition where one sense triggers another**

C) A form of imagination

D) A result of drug use

**9. The inverted spectrum thought experiment suggests that:**

A) Colour is objective and measurable

**B) Subjective colour experience may be fundamentally private and inaccessible**

C) All people see colours identically

D) Colour does not exist

**10. The text concludes that the world we experience is:**

A) An exact replica of physical reality

**B) Constructed by our brains, shaped by senses, language, and culture**

C) Entirely imaginary

D) Identical for all conscious beings