Eye of the Artist

William Ayliffe

Gresham College

30th January 2013

Latticed window in Lacock Abbey in 1835 by Talbot
a print from the oldest photographic negative in existence

Sforza Hours

Book of Hours: collection of Christian prayers for recitation at different times, 'hours', of the day.

For individual use at home: Simplified versions of the eight periods of daily prayer observed by monks and nuns: matins AM to compline at night.

The Sforza Hours decorations painted in two episodes.

Giovan Pietro Birago: Milan court painter . around 1490 for Bona of Savoy, widow of murdered Galeazzo Sforza.

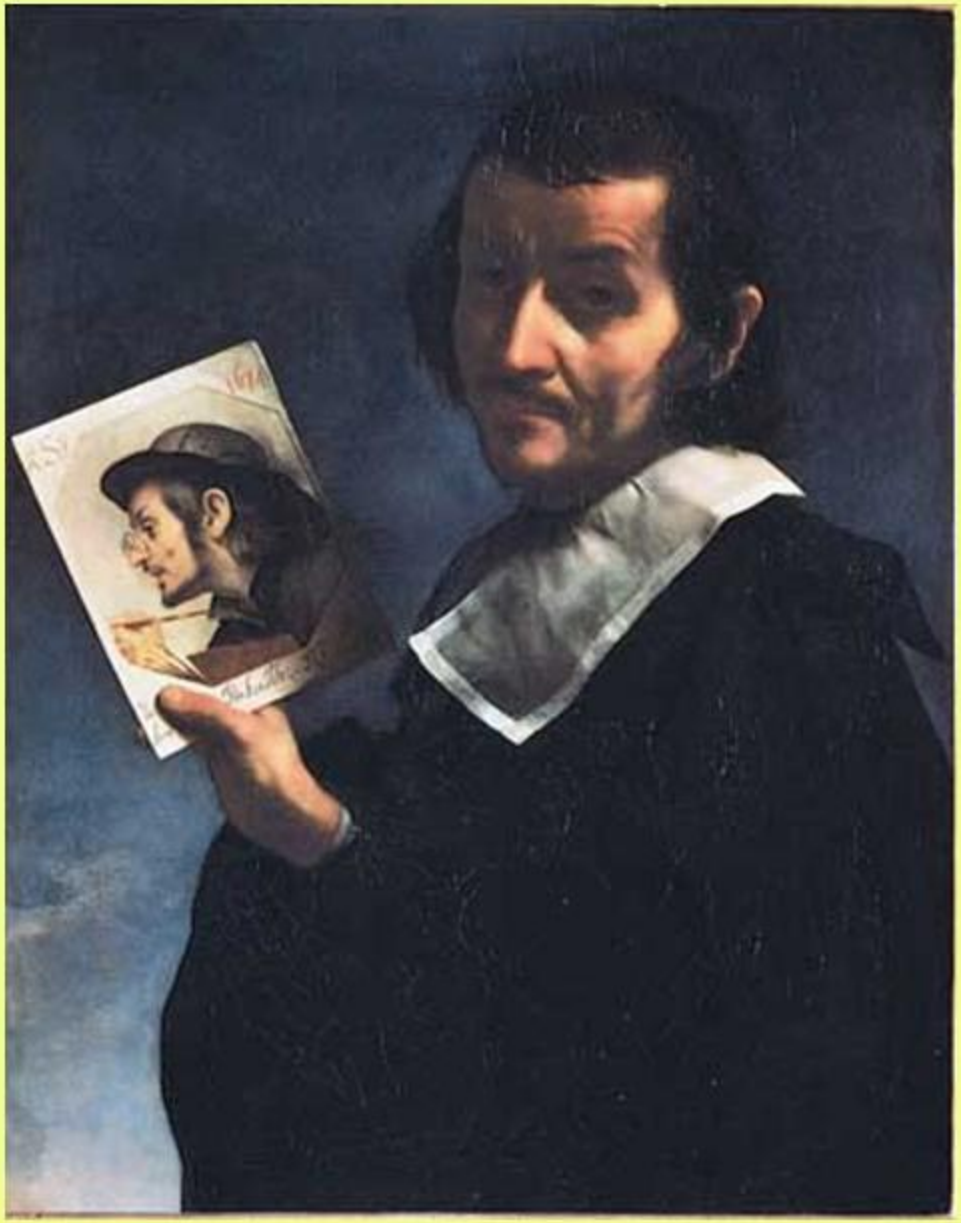
The last of his full-page miniatures appears in the Office of the Dead. The Virgin, awaits death. St Peter, administers the last rites. He wears glasses to read from the prayer book as he sprinkles holy water. The kneeling apostle also uses glasses to read.

second part of the book was stolen completed 1517- 1520, for Bona's heir Margaret of Austria, Regent of the Netherlands, by Gerard Horenbout

Carlo Dolci

1674

At Dulwich exhibition 2007



Quevedo (1580 – 1645)

Francisco de Quevedo y Villegas, R. Ximeno
Madrid, Instituto Valencia de Don Juan

nobleman, politician, poet and writer of the Baroque era.

Style *conceptismo*. rapid rhythm, simple vocabulary, witty wordplay rather than complicated vocabulary.

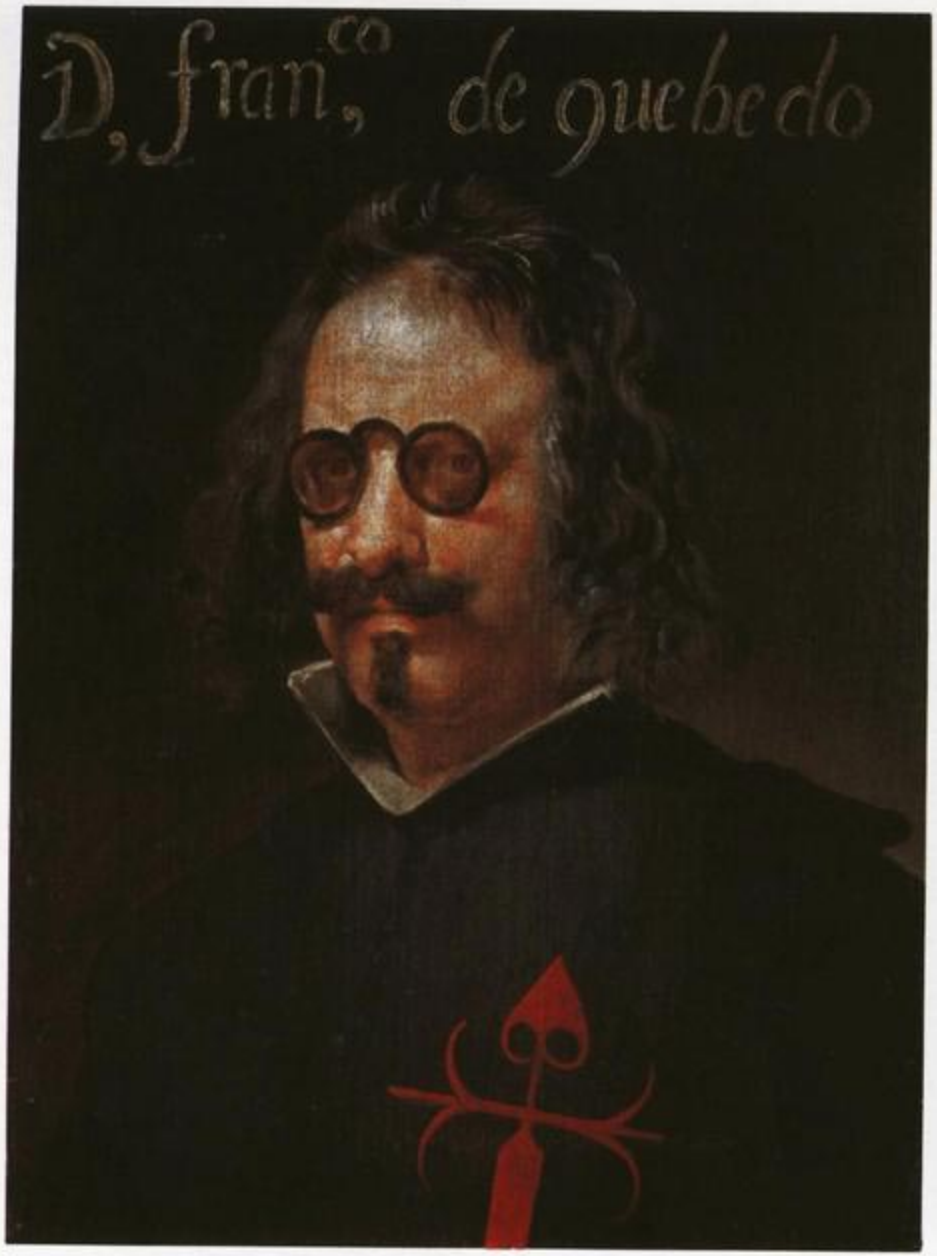
Ayer se fue, mañana no ha llegado,

Hoy se está yendo sin parar un punto;

Soy un fue, y un seré y un es cansad

Intellectually gifted, a club foot, obesity, and myopia.

Since he always wore pince-nez, his name, *quevedos,* came to mean "pince-nez" in the Spanish.



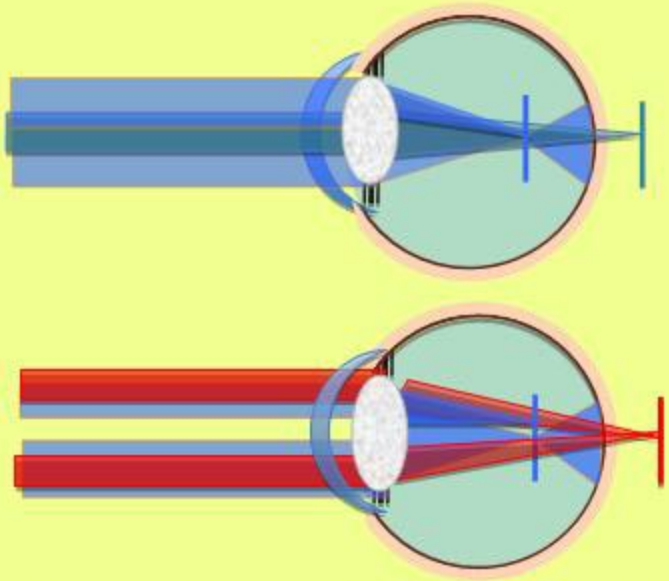
Retinal Image is blurred

Imperfect optics cause aberrations

Spherical

Chromatic

Worse as pupil dilates (nightime)

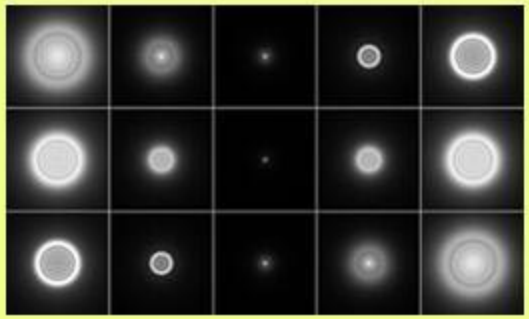


Imperfect image may compensate for chromatic blur. Controversial.

When eye is focused for mid spectrum the blue light is not focussed and cannot contribute to image causing blur.

(Yellow pigment in macula, less blue cones.

However monochromatic blur much larger.



Eye of the artist

The yellowing of our lens with age does contribute to our inability to distinguish black, blue, and brown in dim lighting, but the dim lighting is probably a bigger factor.

The yellowing of our lens means that less blue light gets through to our retinas, but dim incandescent bulbs also contain very little blue light.

The lack of blue light to respond to is what causes these particular difficulties with dark colors.

Turner

Pair of spectacles, the snuff box, magnifying glass and card case all from Maria Tanner who helped clean Turner's studio on Queen Anne Street in Chelsea. Maria Tanner was a friend of the painter's housekeeper, Hannah Danby, and the two women lived on together in Turner's house after his death

Made by Benz.

The case is later 19thC from the optician Stanley Pearce of Wardour Street

-2.5D ? Cataract myopia

Another 2 pairs preserved by Ruskin, the artist's executor, presented to Ashmolean museum in Oxford.

+3 and +4; used for close work.

Astigmatism

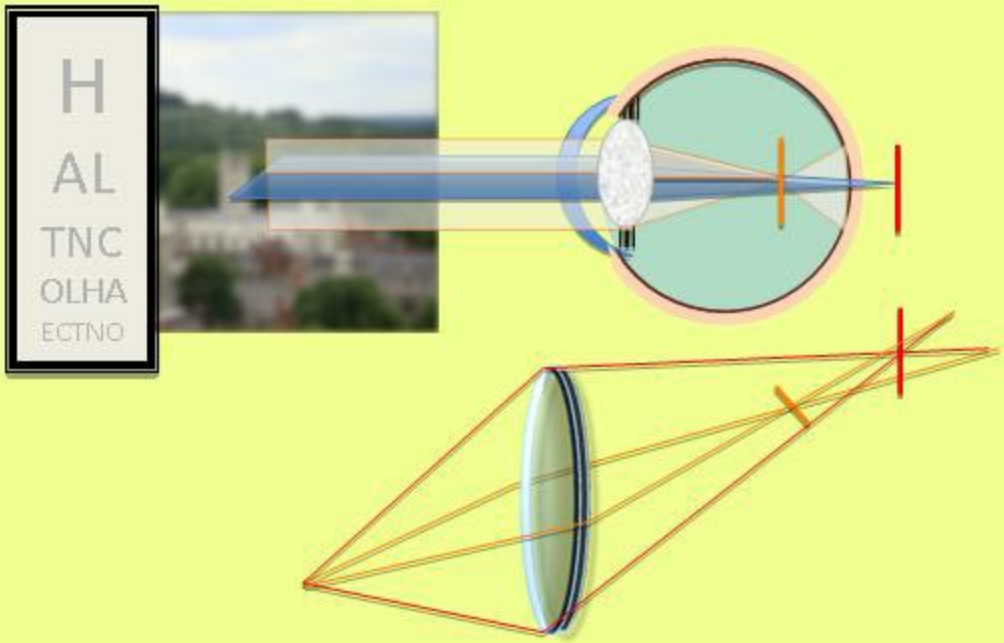
1794: **Thomas Young** mentions his visual defect to the instrument maker William Carey who replies that many people were obliged to tilt a concave lens to see clearly.

Sir George Airy had a higher astigmatism

Whilst a student at Cambridge, he had noticed that images of circles formed elliptical images in his left eye . Developed cylindrical lens to correct the defect.

Paper read Feb 1825 before the Cambridge Philosophical Society. Whewell master of Trinity suggested the term "astigmatism".

1825: Fuller of Ipswich produces astigmatic lenses.



Caricature of Airy, wearing a pair of oval spectacles. (Vanity Fair 13 November 1875)

El Greco

Doménikos Theotokópoulos, (1541 – 7 April 1614)

elongated figures

Astigmatism distorts in one direction

El Greco's elongated distortions did not simply occur in one direction as would be expected with astigmatism; while most of his human bodies are stretched vertically, the fingers are stretched horizontally.

Stylistic: uniting Byzantine traditions with those of Western painting

precursor of Expressionism and Cubism

Saint Martin and the Beggar; 1599: Chicago

The Opening of the Fifth Seal (The Vision of St John), 1608-14, Metropolitan Museum of Art

Realistic representation in art

Shadows
Edges
Movement
How far away
3D shape
Object from background
Overall organisation

Object recognition
Colour

Symposium scene in the Tomb of the Diver at Paestum, Campania *c 480 BC*

Illusionistic art: EH Gombrich: (Art and illusion): Greek **mimesis** the imitation of nature; took 250 years to accomplish. The Renaissance took the same time period to eliminate falseness in pictures.

Since no image looks like nature some argue that the proper discipline to investigate pictures is semiotics not psychology of perception.

Zeuxis and **Parrhasius** (of Ephesus and later Athens)

Pliny the Elder *Naturalis Historia* describes a contest to determine which of the two was the greater artist. When Zeuxis unveiled his painting of grapes, birds flew down from the sky to peck at them.

Zeuxis then asked Parrhasius to pull aside the curtain from his painting,

'I have deceived the birds, but Parrhasius has deceived Zeuxis

Zeuxis b Heraclea c464 BC arrogant, not popular, even disliked by Aristotle. A client ordered a painting of Aphrodite and requesting herself be used as his model. After viewing the completed painting of the old crone he laughed to a paroxysm and died.

THANK YOU

Centre-surround

In real world a wide range of luminance

Cannot be reproduced by pigments.

Photos and paintings cannot do this

Artist needs to compensate for fact that pigments not available that reflect range of luminances in real world.

Centre-surround makes us respond to abrupt change

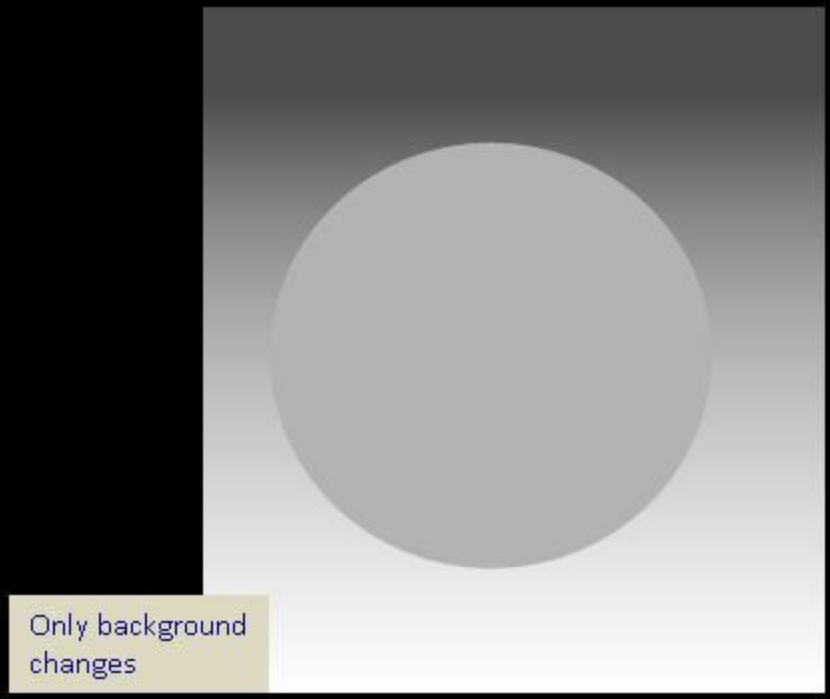
We don't need to code for 1,000's of luminance steps

Just where things are locally different from the background

do this by gradual changes in background stimulating an opposite shift in the foreground.

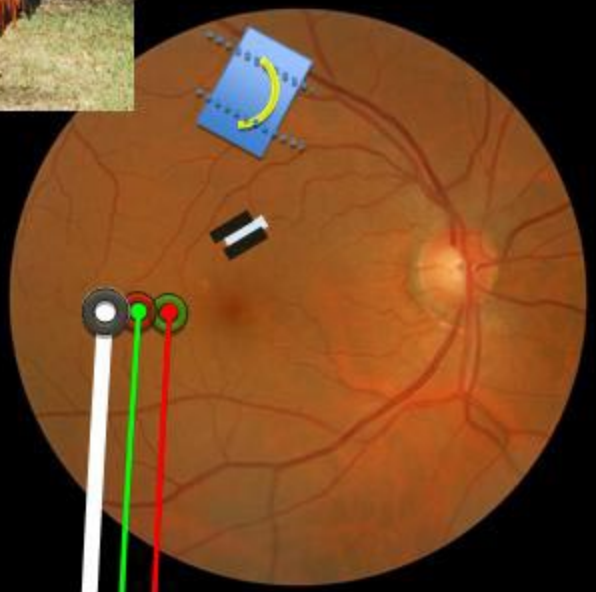
Shading

Seurat:



Only background changes

Constructing the visual scene



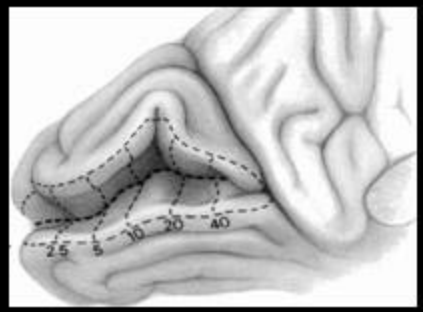
V4
Colour Visual Acuity
Form

V5
motion
Stereo
depth

V2

I
2
3 Complex cells
4 Simple cells
5
6

V1



P-cells

M-cells

two-streams hypothesis

model of the neural processing of vision.

humans possess two distinct visual systems.

Segregation begins in retina

Large & Small GCs

Relay in Thalamus

visual information passes on from occipital lobe striate cortex, in two pathways.

dorsal stream ("where/how pathway")

Travels to parietal lobe

processing the objects spatial location related to viewer.

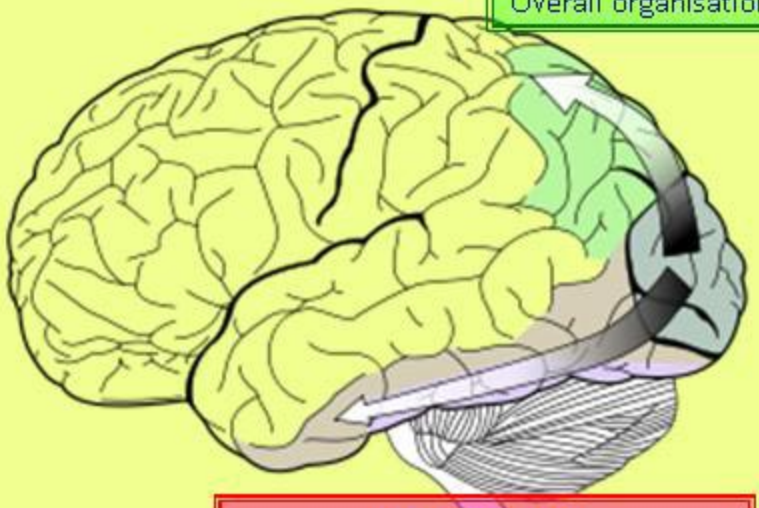
ventral stream ("what pathway")

travels to the temporal lobe

object identification, colour and recognition.

1992: David Milner and Melvyn A. Goodale

WHERE: older.
Motion
Space,
Position
Depth
3D
Figure/ground
Overall organisation of scene



WHAT: primates
Form System:
uses colour and luminance to determine shape
Colour system:
low resolution, colour of surfaces

interaction between vision-for-action and vision-for-perception.

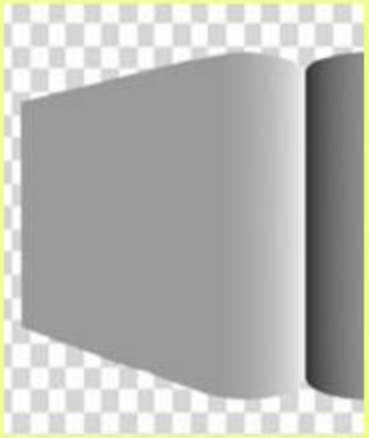
Mach bands

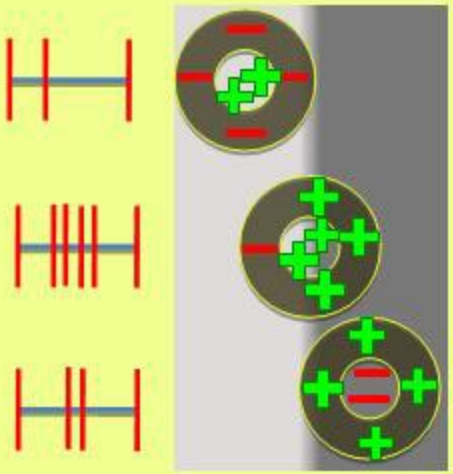
Optical illusion: areas of different luminance separated by a gradient. Perceive 2 narrow bands of different brightnesses either side of the gradient not present in the original image.

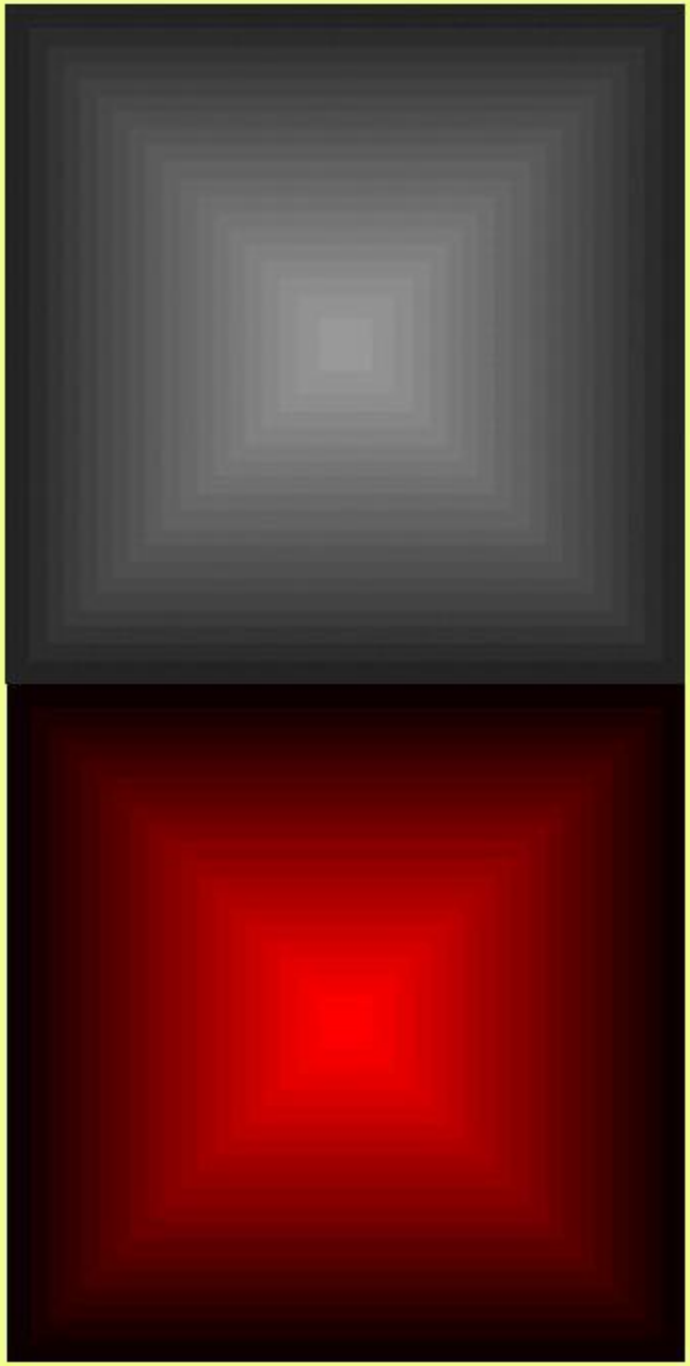
Originally explained by centre surround (lateral inhibition) of retina.

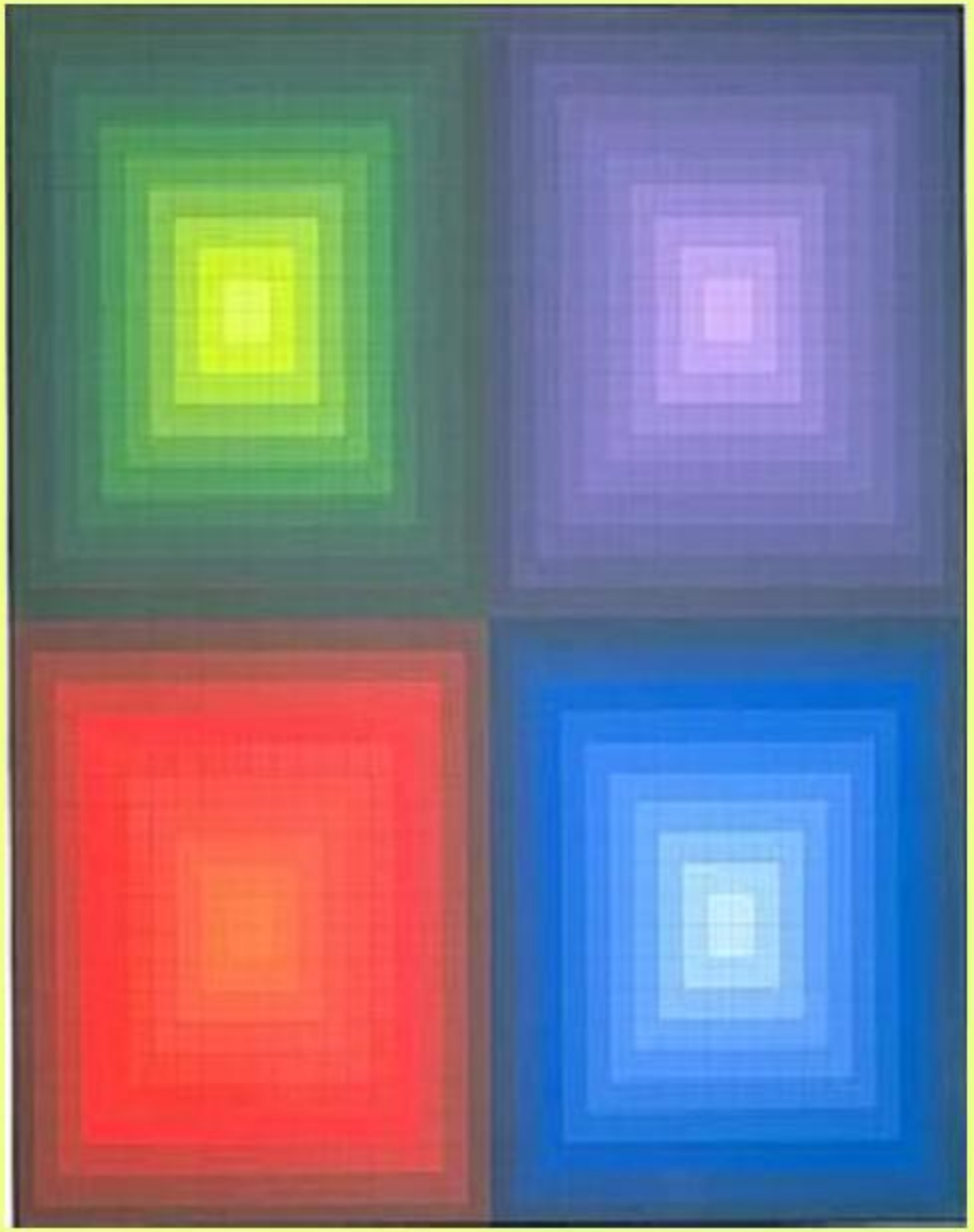
Dale Purves: Because of the properties of reflected light, curved sufaces typically exhibit "highlights" and "lowlights," which are essentially the same as Mach Bands.

Curved surfaces more likely to exist in nature than gradients on paper.









Arcturus II,1966: Victor Vasarely

The brighter bands at 45 and 135 degrees are illusory

Illusionist art in ancient world

C1st BCE, walls were decorated with architectural features and trompe l'oeil.

Architectural style, 'illusionism'

The picture plane placed behind wall by using painted architecture

Achieved by shadows

Mach bands give realistic impression of changes in illuminance.

Counteracts claustrophobic effect of small, windowless rooms in Roman houses.

Still life in the Second style. Fresco from the home of Julia Felix, Pompeii

The Arnolfini Portrait 1434 Jan van Eyck.

Giovanni di Nicolao Arnolfini his first wife Costanza Trenta, who had died by February 1433, in their home at Bruges

Illusion of curved edge by gradient and dark and bright bands

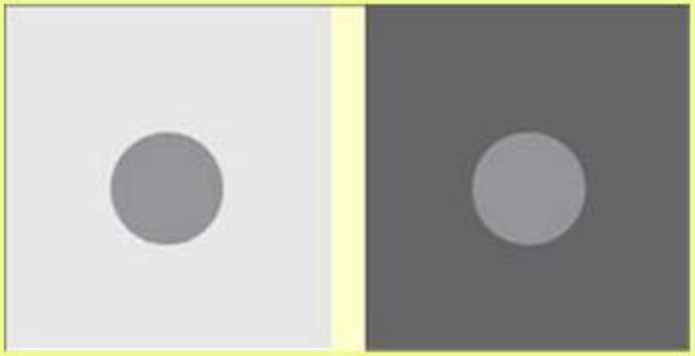
Johannes de eyck fuit hic 1434

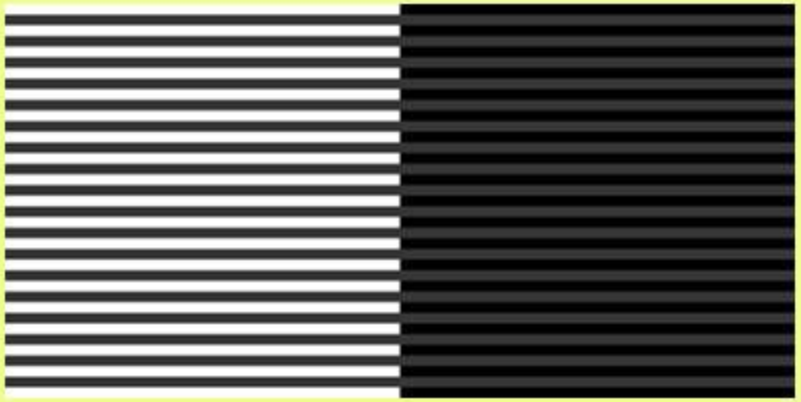
Under some circumstances targets surrounded by areas of **higher** luminance can be made to look **brighter!**

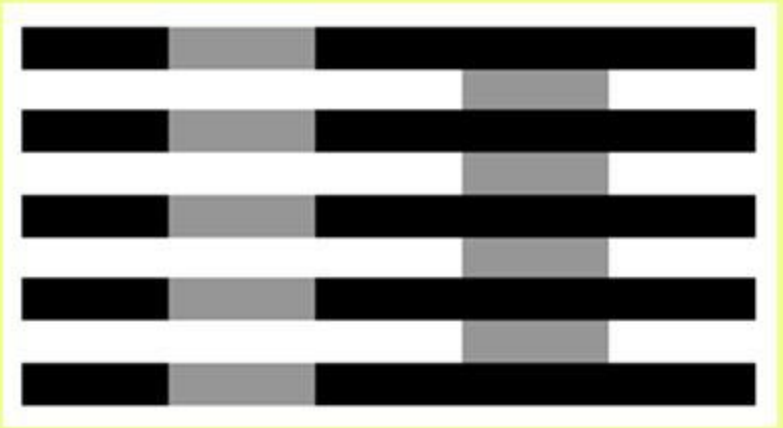
Wilhelm von Bezold (1837–1907)

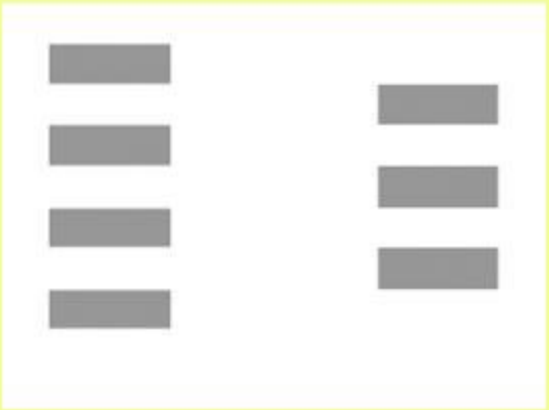
White's illusion

Opposite of SBC









Cornsweet edge: opposing gradients make identical regions look differently bright.

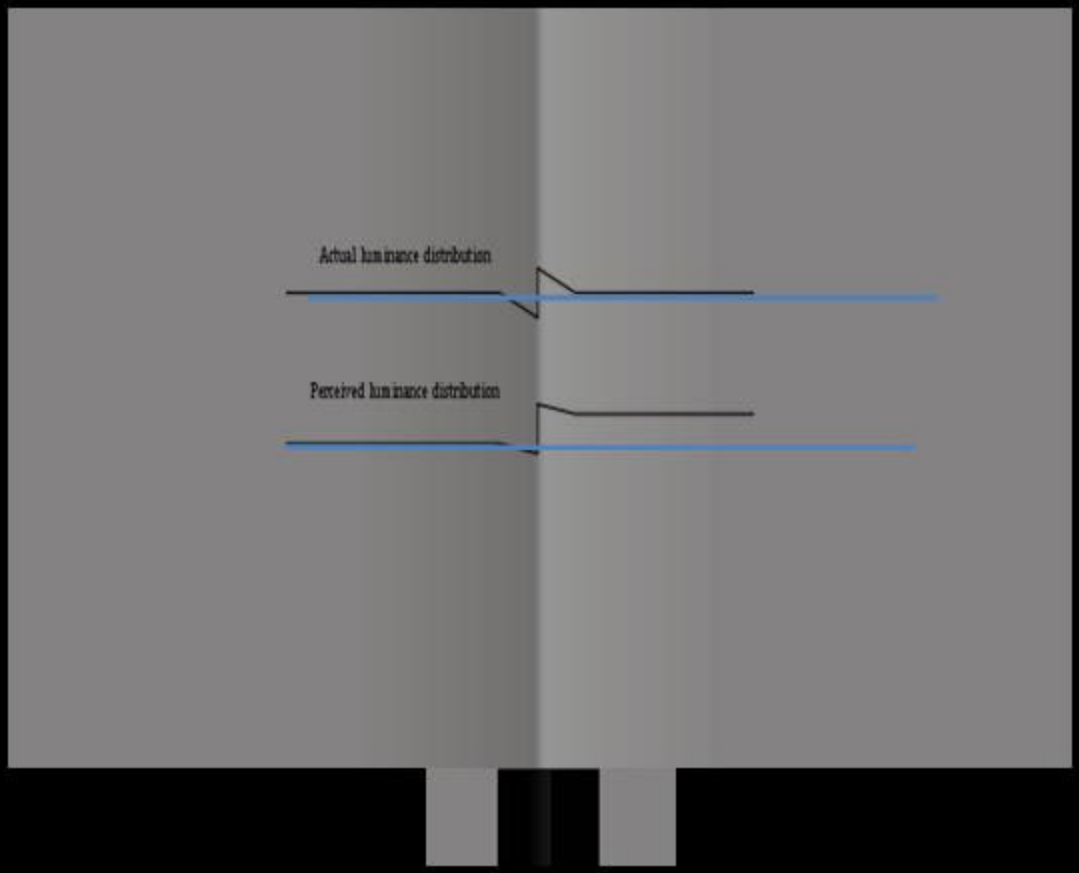
Opposite of SBC

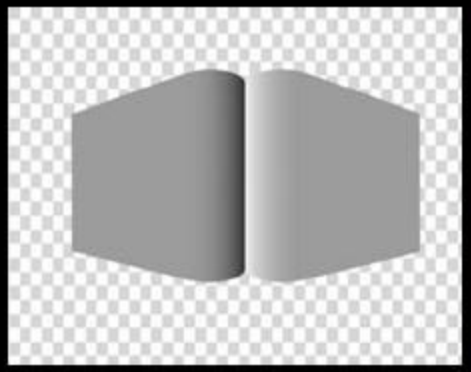
Lotto argues that past experience tells us what is the most likely thing the stimulus is consistent with.

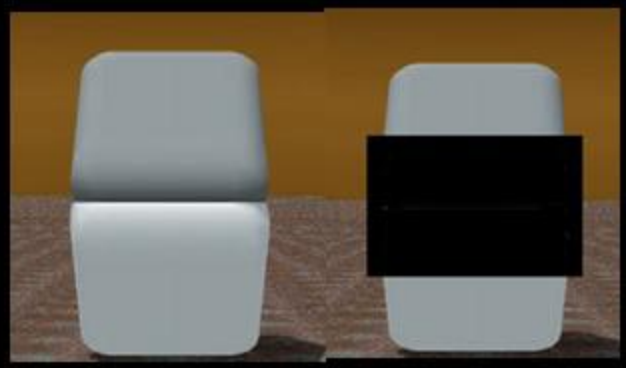
It could be painted gradients on flat paper but in real life surfaces having different reflectance under different lighting more likely eg A cube

so 2 surfaces with a gradient should look differently bright.

Things that are the same need to look the same under different lighting to be useful







The Journal of Neuroscience, 1999, 19(19):8542–8551

The World Through Blunted Sight: Inquiry into the Influence of Defective Vision on Art and Character: Patrick Trevor-Roper 1997

Vision and Art: Margaret Livingstone

David Hubel

The eye of the Artist: Michael Marmor, James Ravin

Tony Harris

Rafael Pepper

Wikipedia

The window appears very bright

Sunlight reflectance from print

Room light

In reality the pigment reflects only 15x more light than the dark shadow area.

Margaret Livingstone

The Philosopher in Meditation, 1632: Rembrandt
Louvre

Use of luminance gradients in art

Hsu Tao-ning:

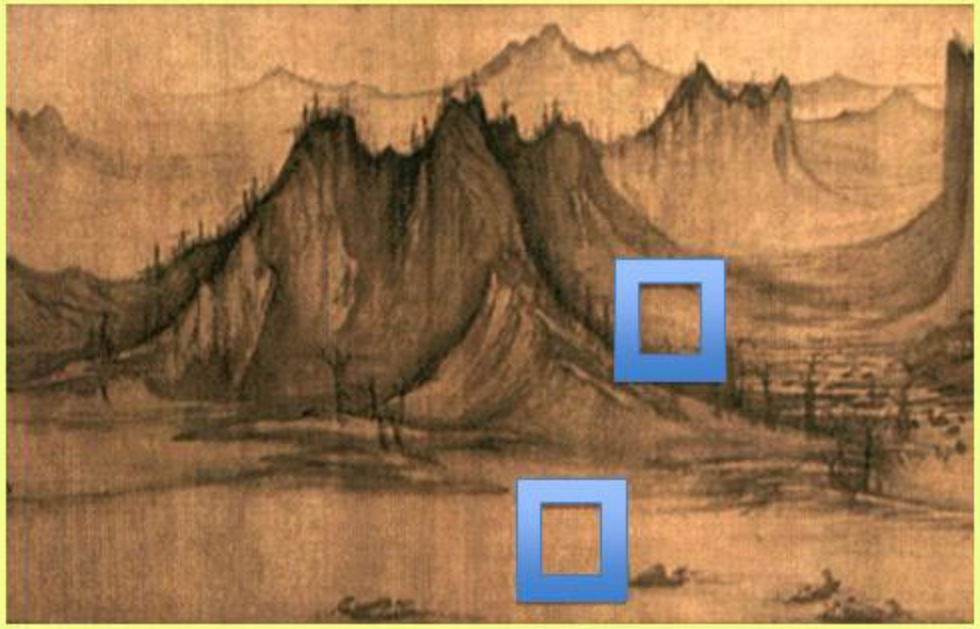
Evening Songs of the Fishermen (970-1052)

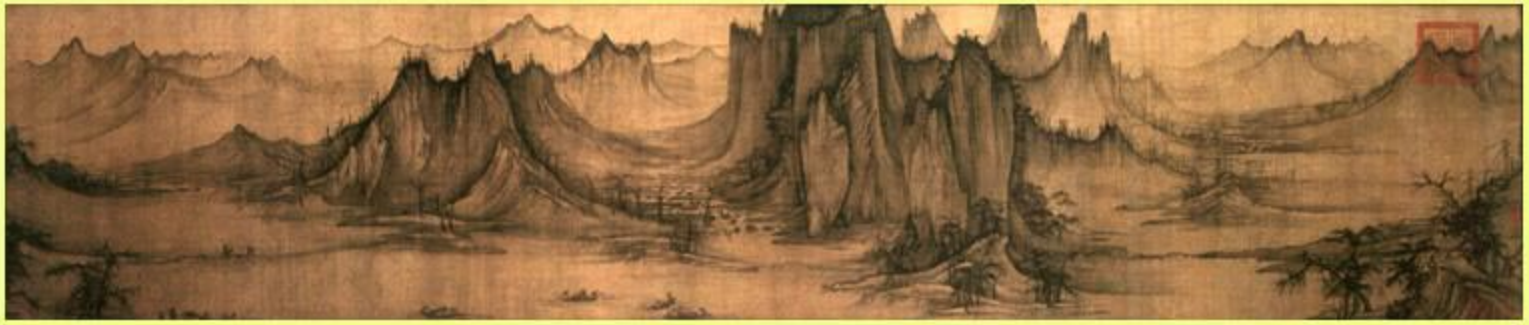
painting while selling medicine in K'ai-feng, the capital of the Sung dynasty;

Lightness and dark portrayed by shading not solid colours

Gradients outline mountains giving illusion of darkness. Actually same as river.

(Michael Marmour)





Portrait of Daniel-Henry Kahnweiler, 1910,
The Art Institute of Chicago. Picasso

"What would have become of us if Kahnweiler hadn't had a business sense?"

A second luminance channel for night vision

natural illumination at night comes primarily from the Moon, the Sun (indirectly), starlight, zodiacal light and airglow

The Moon poor reflector: The Moon's albedo is 0.136, only 13.6% of sunlight incident on the Moon is reflected.

Full moon 500,000x dimmer than the sun.

How do we see? Rods

moonlight is simply reddish sunlight

Reflected from a surface with an albedo larger at longer wavelengths.

But painters use blue for night scenes.

Surprising: moonlight is redder than sun-light;

Rods are more sensitive to light and shorter wavelengths than cones

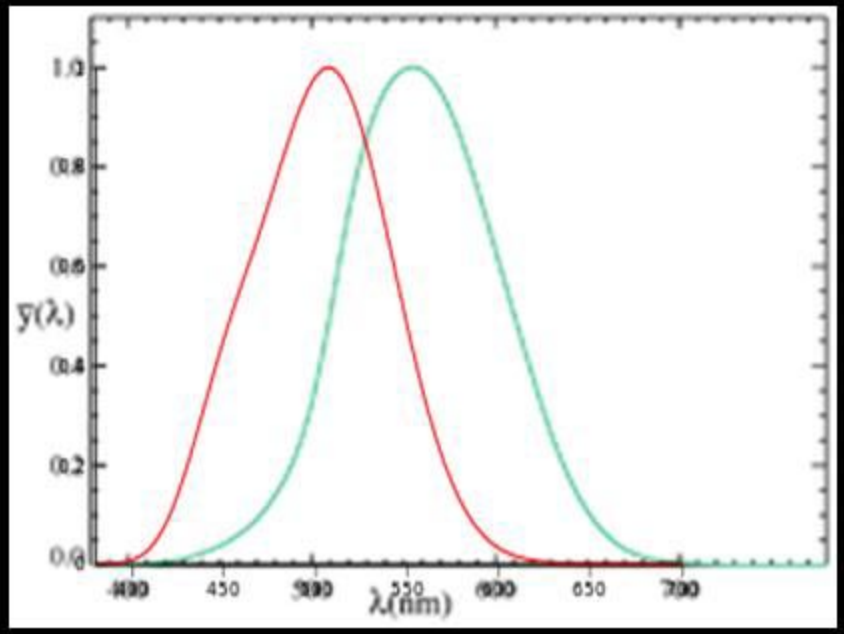
Less sensitive to red

Only one type of rod so cannot generate signals for comparison by GC's to generate colour information.

Purkinje shift: As lighting dims the cones start to phase out (not enough light to stimulate them fully).

The reds become darker and the blues brighter

Affects how paintings are viewed and created.



Très Riches Heures:

book of prayers to be said at canonical hours

created for John, Duke of Berry.

Paul de Limbourg and his two brothers, Jean and Herman 1412-16.

After their deaths the book was completed by an intermediate painter and later Jean Colombe between 1485 and 1489.

Black and grey symbolise, fear, superstitions, evil, death, sorrow.

The light source in religious paintings symbolises divinity (guidance, hope).

Très Riches Heures du Duc de Berry, *Christ in Gethsemane, c. 1411-1416 Limbourg brothers. Musee Chantilly*

The color of moonlight, particularly near full moon, appears bluish to the human eye compared to most artificial light sources.

the light is not actually blue

Receptors see short wavelengths as brighter

Cannot see red things very well at all

although moonlight is often referred to as "silvery"

it has no inherent silvery quality.

Dovedale by Moonlight: Joseph Wright of Derby

Non colour cues to indicate night time

Ma Lin, Waiting for Guests by Lamplight, circa 1250 (China, Song Dynasty)

Turner first oil painting
Royal Academy 1796,

cold light of the moon

Warm glow of the fishermen's lantern

Poor detail in peripheral field of vision

Fishermen at Sea. A nocturnal moonlit scene,

differences between rod and cone vision

change in the quality of white, silky sheen;

reduction in spatial resolution , reduces details;

edges are still seen

Reduction of depth perception

The shift to scotopic vision produces a pale grey; greenish-blue scene

Shapes with lighter value characterized by outline

Dark shapes lose internal (low contrast) detail

very small things cannot be discriminated

Detection of rapid movement reduced

Archip Kuindshi, Night on the Dnieper River 1882.

Line detectors

Visual cortical cells respond to orientation

visual cortex organised as columns.

Info from RE separate column from LE.

Two major classes of cells simple and the complex.

Each cell responds to particular orientation

For any spatial location representation of various orientations.

respond best to **moving** line

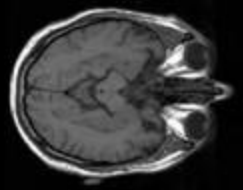
Flashing a stationary line on and off evokes weak responses

Size: near fovea 0.25^0. (moon 0.52^0 150µm)

In periphery 1^0 (288µm)

Activation of ON cells elicits the perception of lightness,

activation of OFF cells elicits the perception of darkness.

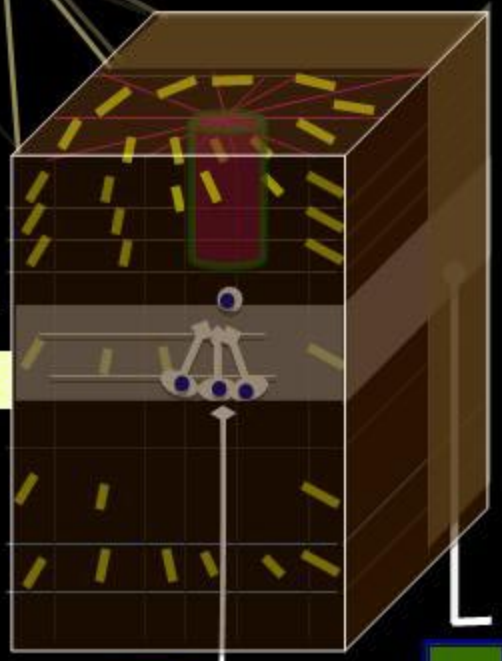


Stereopsis (depth perception)

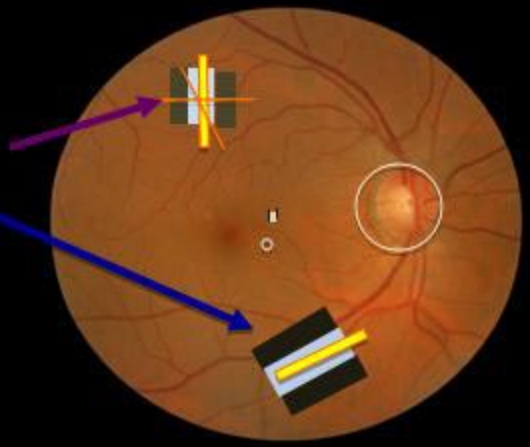
Disparity between the two sets of information allows the brain to construct a realistic impression of depth

Complex

Simple cells



Orientation of stimulus



The link between the eye and objects: Light

Immersed in a sea of electromagnetic radiation waves interact with each other and objects to present a cacophony of electromagnetic signals (Fenyman).

Reflected off opaque and transmitted through transparent material.

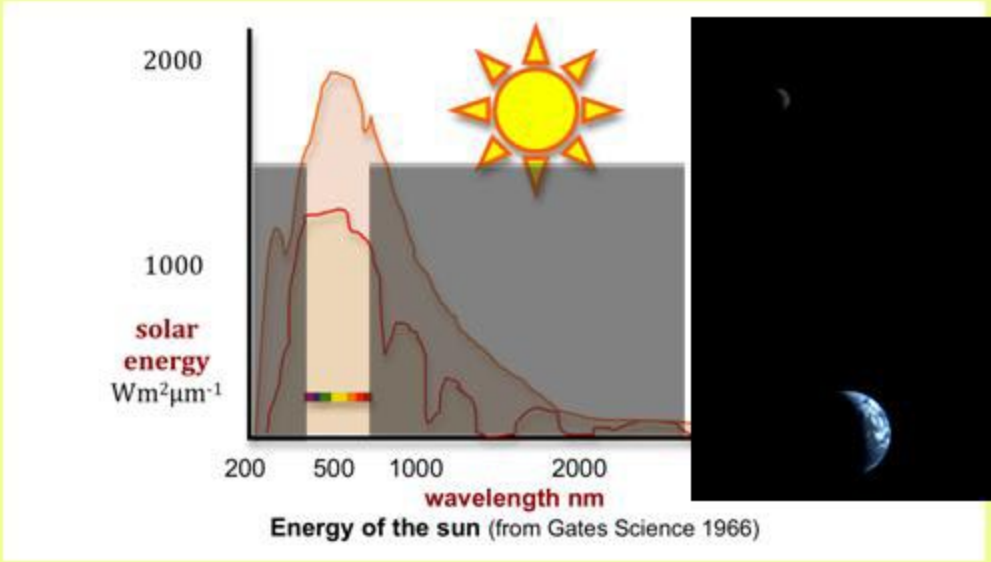
Skylight.

Through a tiny aperture the eye collects a small fraction of the energy.

Some of this (400-700nm) is used to create the sensation of light.

Light is like any EMR: Special to us because we have receptors

~10% of photons are captured, 3% reflected, rest miss the target and absorbed by non-seeing structures.



Energy of the sun (from Gates Science 1966)

Illusion of lines

Domenico Ghirlandaio (c 1448-1494)
Florence's most successful workshop

Michelangelo attended aged 12 in 1487

Frescoes for the choir chapel in the church of Santa Maria Novella illustrating life of the Virgin and St John the Baptist,

study for *The Birth of the* Virgin

principal aim is the arrangement of the figures.

blank ovals for heads and blobs as hands –

technique also used by Michelangelo in some of his preliminary sketches.

The Birth of the Virgin: Domenico Ghirlandaio:
pen and brown ink: 1487 BM

Michelangelo di Lodovico Buonarroti Simoni 1475-1564

Raphael died 1520,

claimed to be entirely self-taught, Ghirlandaio's influence

dominates the Roman art for 40 yrs.

Mostly drawings of male body never intended for public display.

Destroyed a large number before he death.

1508, Pope Julius II commissioned Michelangelo to paint the Sistine chapel ceiling in the Vatican

Most beautiful are the ***ignudi*** - the seated nudes holding swags which keep the bronze medallions upright

Study for Adam 1510

Study for a figure of a man. Louvre: 1503

Pablo Picasso (1881–1973)

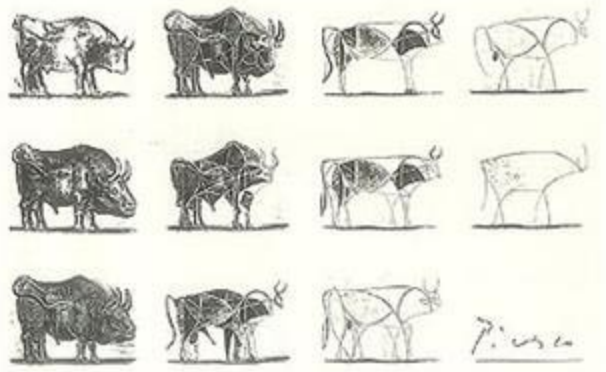
one of greatest draftsman of the 20th century

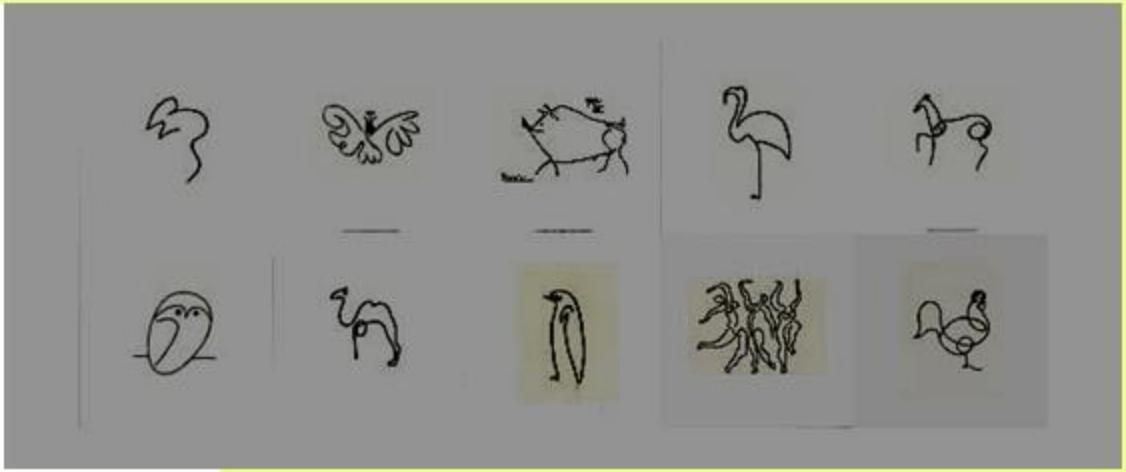
particular attachment to a dachshund called Lump who became famous for eating a Picasso piece

Le chien

Pablo Picasso*Self-Portrait, 1901/1902*
Ailsa Mellon Bruce Collection

Pablo Picasso (1881–1973), *Young sculptor at work, plate 46 of the Vollard Suite. Etching, 1933.*





Processing form

Walter Ehrenstein (1941).

brightness enhancement at the centre

Objects in the natural environment are often partially obscured.

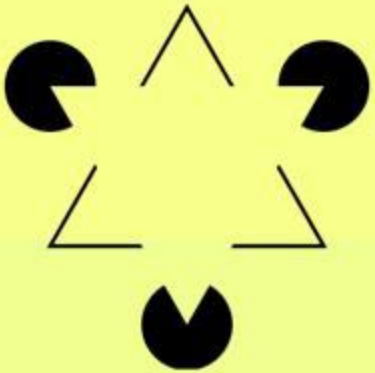
Using a stastistical based problem solving mechanism the brain assumes that the lines are continuous behind the disc.

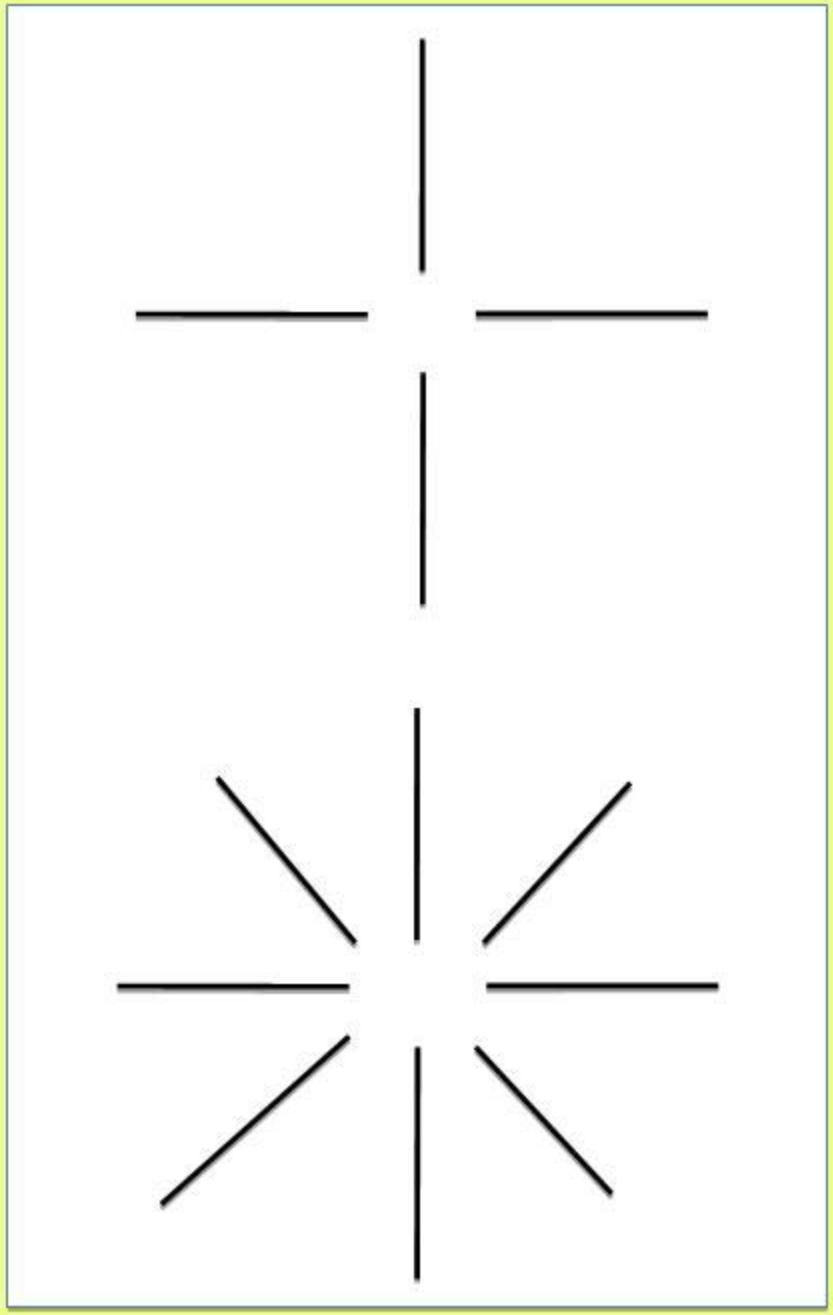
visual system is filling in the field that is receiving no information.

Illusory contours occur from activity of "dedicated" mechanisms critical for survival

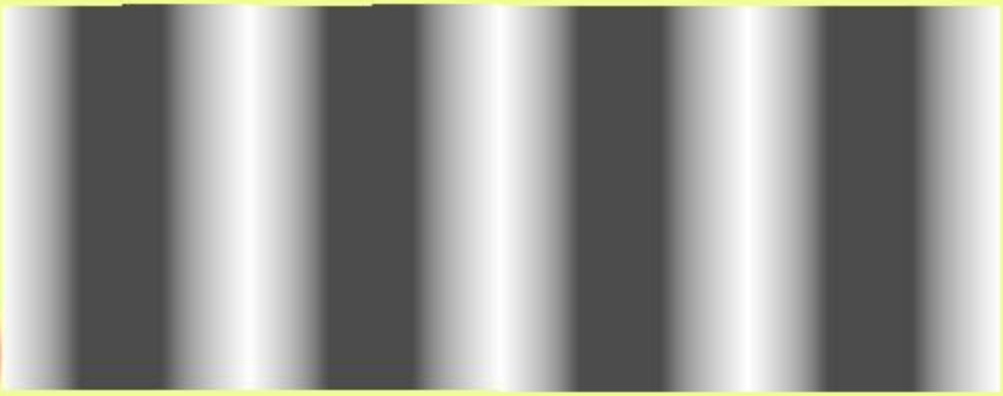
have to be fast and efficient

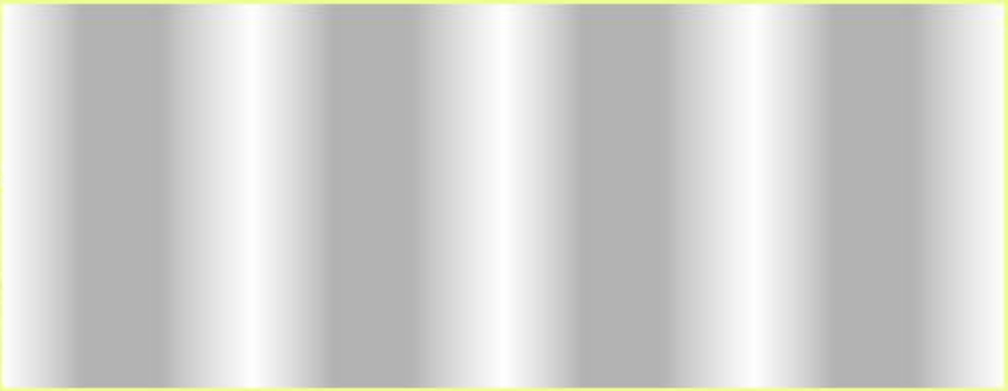
more cells in V2 than V1 are excited by the Kanizsa-square

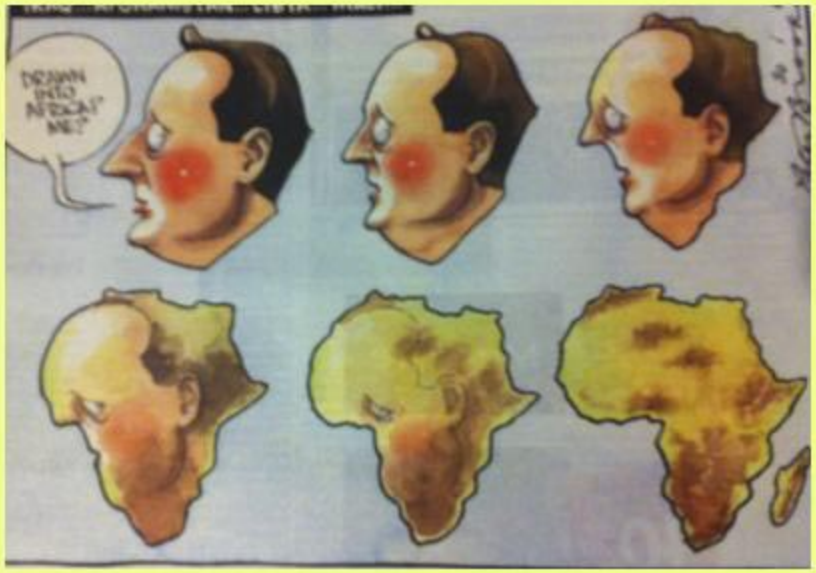


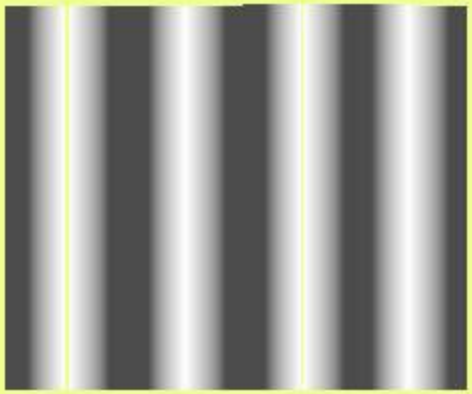


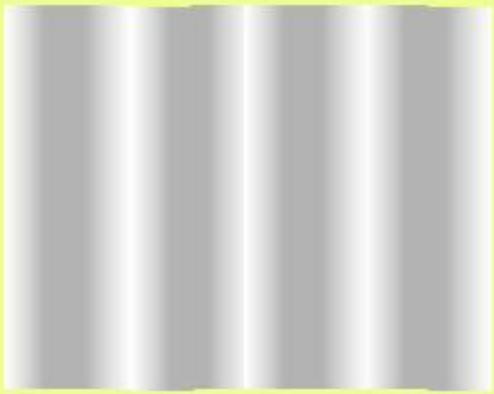
Acuity/ Contrast











Peter Brookes
Times 30/1/13
With permission

Acuity

Poussin's *Death of Germanicus, 1628*
Minneapolis Institute of Arts;

Higher resolution of the face
Less detail peripherally

'Woman with Crossed Arms' by Dante Gabriel **Rosetti, at Wightwick Manor.**

Jean-Auguste-Dominique **Ingres,**

Mrs. Charles Badham,
née Margaret Campbell, 1816,
National Gallery of Art, Washington, DC

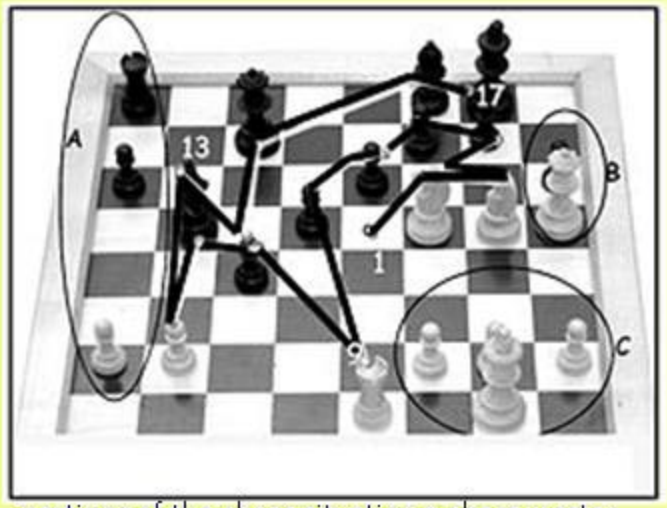
Peripheral vision

peripheral vision is qualitatively different from foveal vision in some rather strange way:

One either sees something black of indetermined form or one sees two points (Aubert & Foerster, 1857"

Things are less distinct as they lie farther from my gaze. It is not as if these things go out of focus—but rather it's as if somehow they lose the quality of form" (Lettvin, 1976)

In peripheral vision, the recognition of detail is severely impeded by patterns or contours that are nearby. crowding



portions of the chess situation a chess master can reproduce correctly with his peripheral vision. Lines show path of foveal fixation during 5 seconds when the task is to memorize the situation as correctly as possible

Peripheral vision and pattern recognition: A review: Hans Strasburger JOV 2011

A distinct anatomical network of cortical areas for analysis of motion in far peripheral vision S. M. Palmer, M. G. P. Rosa: EJN 2006

Peripheral vision

Ehlers: normal reading and acuity charts, visual difficulties recognizing letters among other letters in eccentric vision; independent of angular letter size

Density of receptors decreases toward edges.

Peripheral vision is good at **detecting motion**.

More important than central vision for **scene recognition**.

Wired up differently

Representation of the far periphery in MT receives specific connections from V1; Medial Superior Temporal and retro-splenial cortex.

No input from other extra-striate areas

Skylight: scattering of short wavelength light by air molecules. though much dimmer than the sun's disk, sky is X100,000 larger.

Illuminance contribution of skylight is significant: why we can read in shade.

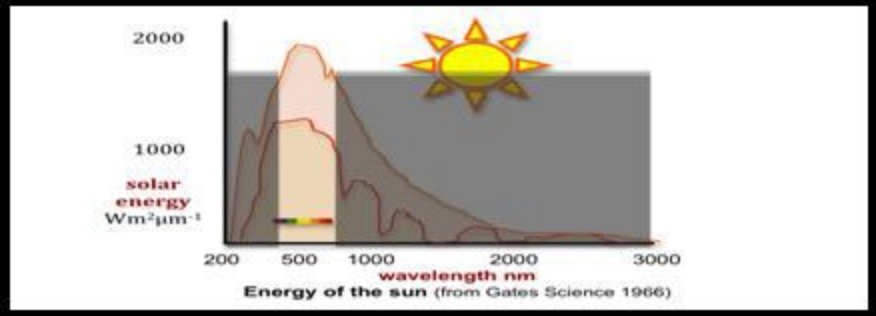
Different surfaces absorb (and reflect) light in different parts of the spectrum due to their chemical composition

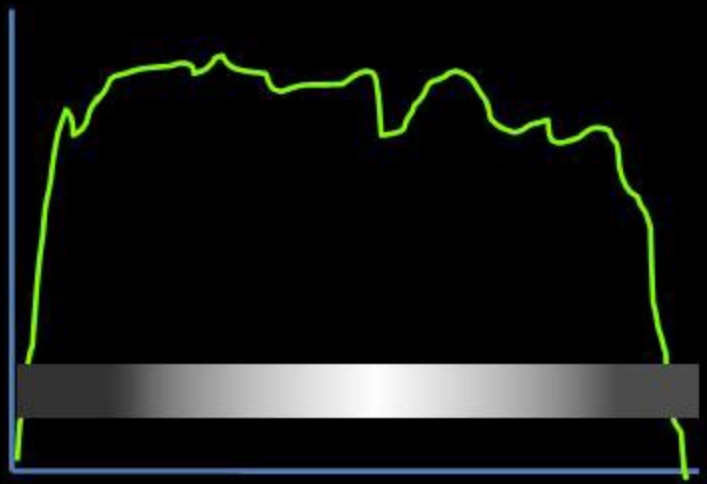
The eye uses chemicals which absorb better in some wavelengths to trap light

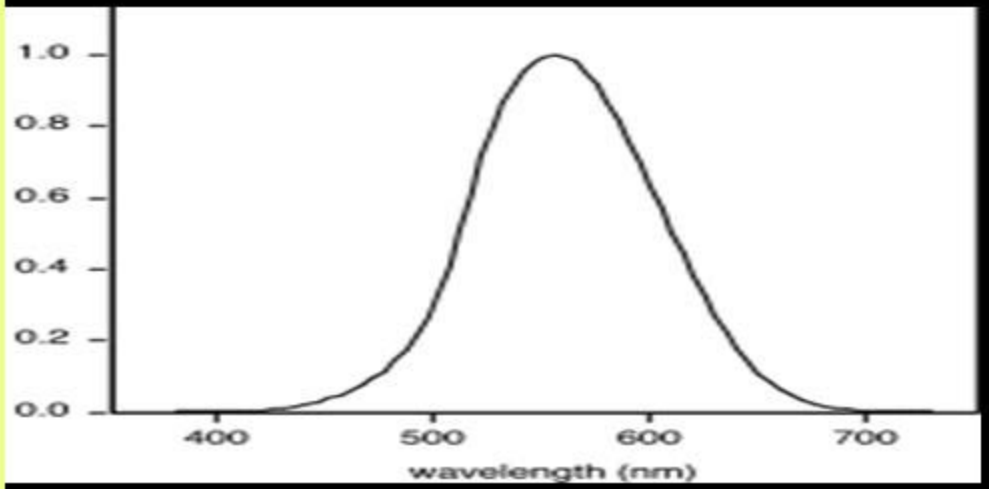
Light of **equal energy** but **different wavelength** appear **differently bright**

A **lumen** of light, whatever its wavelength (colour), appears equally bright to the human eye

Wavelength, nm	Lumens/watt	Watts/lumens
400	0.27	3.704
450	26	0.038
500	220	0.005
550	680	0.001
600	430	0.002
650	73	0.014
700	2.8	0.357







Colour

Newton:

Orange remained orange

spectral "orange" light was just as primary and simple as "red" or "green" light, because none of these hues by itself could be altered or separated by refraction into any other colors.

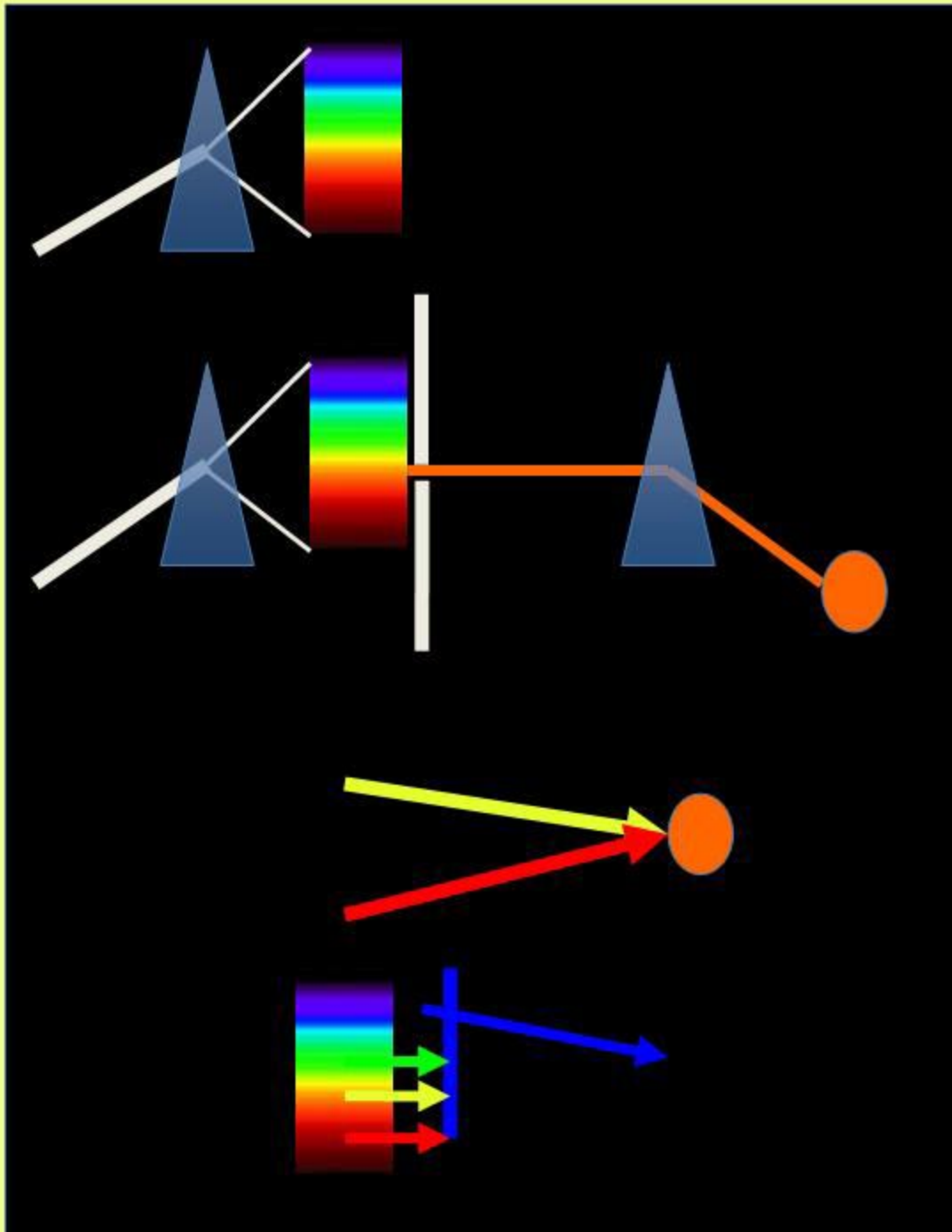
refuted the color theory inherited from Aristotle, in which "light" and "dark" were the two antagonistic primitives that mysteriously combined, like an oil slick, to create colour.

the stimulus is perceived as color only through **attributes of mind**: ***"The Rays to speak properly are not coloured***

Light of 640nm looks red

0.000004" shorter (100nm)

540nm looks green



Pseudodionysian light metaphysics

Abbot Suger, friend of Louis VI and Regent to his son, reconstructed the choir of St. Denis, Benedictine Priory. 1140-44. Glazed the upper Choir "Nova Lux"

Used stained glass with much expensive blue.

Pseudo-Dionysius (Denys) C5th anonymous theologian. Ascribed to Athenian Convert of St. Paul Acts 17:34 D. the Areopagite

Neoplatonic early medieval: Light a direct emanation from the divine

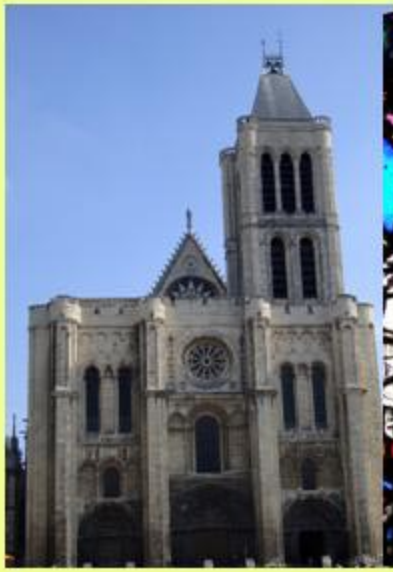
The primary light Lux is substance distinguished from light of heavenly bodies Lumen which flows from it

Lux = Divinity:

Gift of Byzantine Michael the Stammerer to Louis the Pious at Compeigne 827

Charles the Bald comissions **John Scotus** to translate

"Quid Distante inter Sottum et Scottum"



Art judged by its physical as well as the metaphysical aspects of the raw materials.

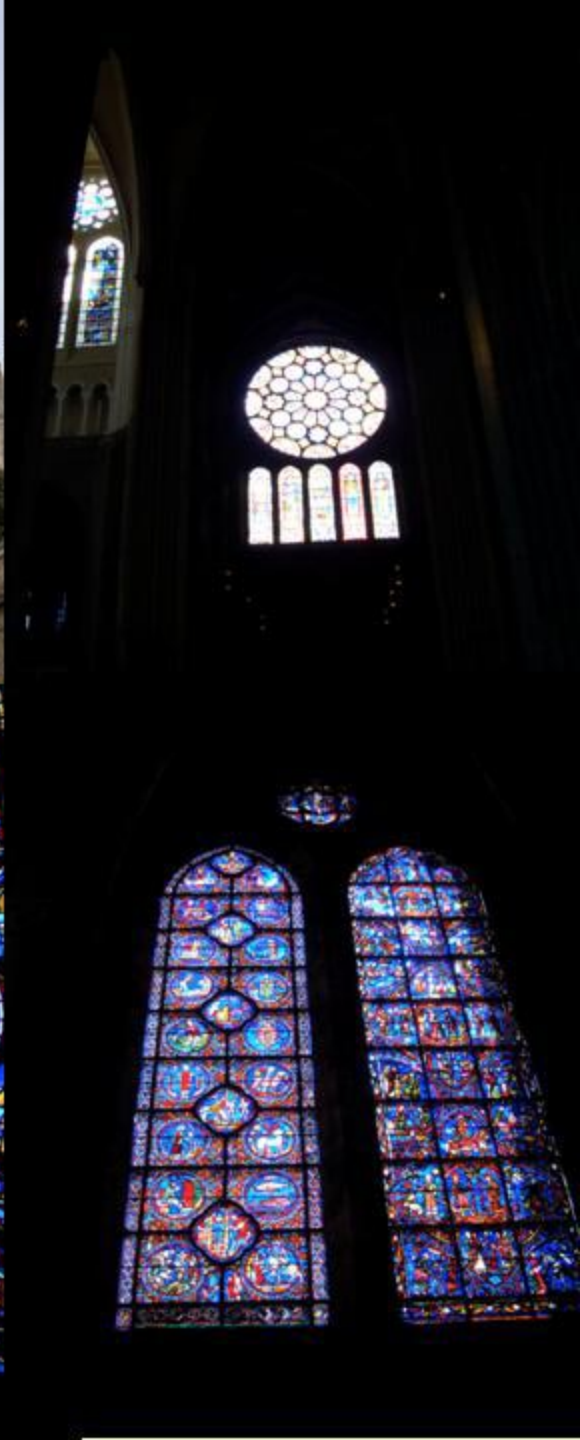
Suger quotes Ovid

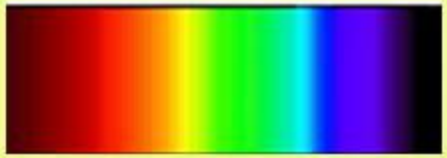
Materium superbat opus

The workmanship surpassed the material

Suger presenting glass window

Suger at foot of Virgin in infant of Christ window





Discovered a region of new colours that did not appear in a prismatic spectrum.

Extra-spectral hues

"violet" (purple),

"red violet" (magenta),

"violet red" (carmine)

"red" (unique red)

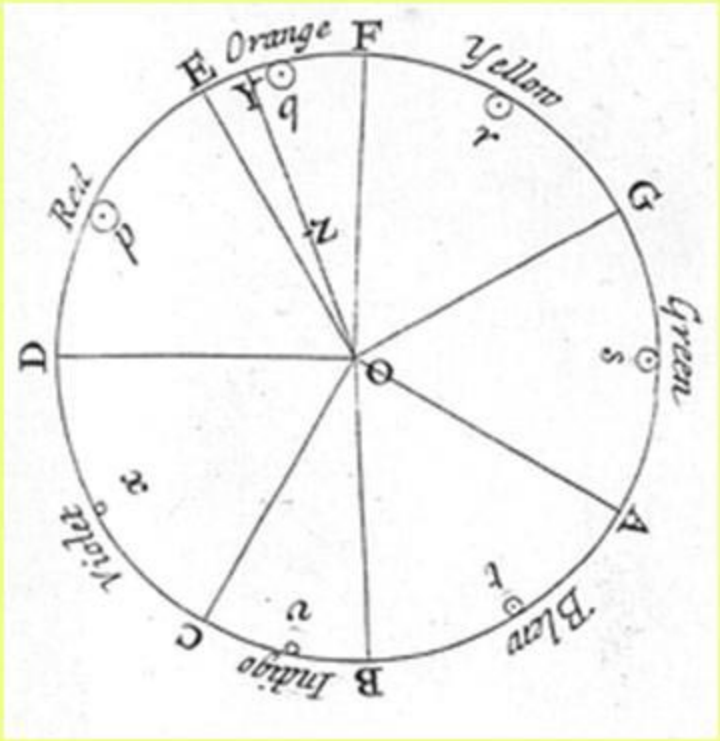
appeared by overlapping the "orange red" and "blue violet" ends of two separate spectra

known in nature: gems flowers

New color model: "red" and "violet" ends of the spectrum joined to create a **hue circle.**

only applies to light mixtures.

Pigment mixtures do not depend on the quantities of pigments in a mixture, but on *"the quantities of the Lights reflected from them."*



two hues on opposite sides of the hue circle could create a near neutral color if mixed in the right proportions:

origin of the idea of complementary colors

Newton's parallel experiments with pigments and lights confused C18th century "color theorists" into thinking that pigments and lights mix in the same way,

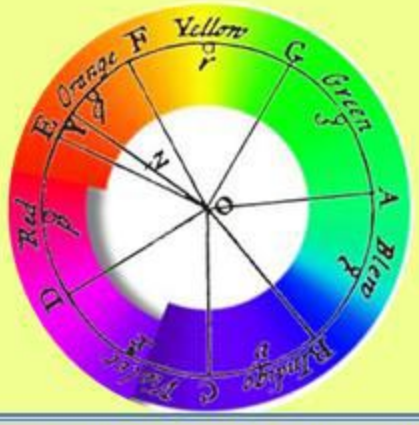
Opticks uses the circle to explain colour mixtures, a tool for mathematical analysis of hues in a color mixture.

linkage between physical quantities and sensory qualities principle of psychophysics.

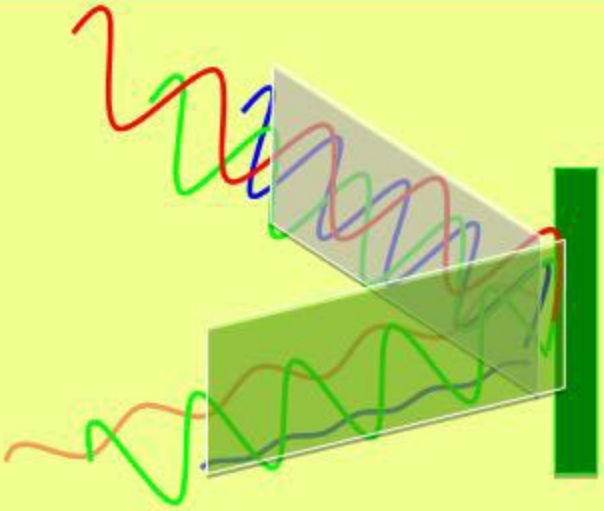
all color arises in mixtures of light, whether the light comes from a prism or reflected qualities of powders.

Colours appear from surfaces painted with pigments because they reflect some spectral colours and absorb others.

C17th century dyer's lore that three primary colored paints or dyes defined colour mixing.



Ancient theory is partly correct. Colour is created by the partial "darkening" of "white" light by matter.
Aristotelian theory not specific about the mixture process that allowed just two primitives to produce all colours
Colours result because some of "primary" colors of light are absorbed or darkened more than others

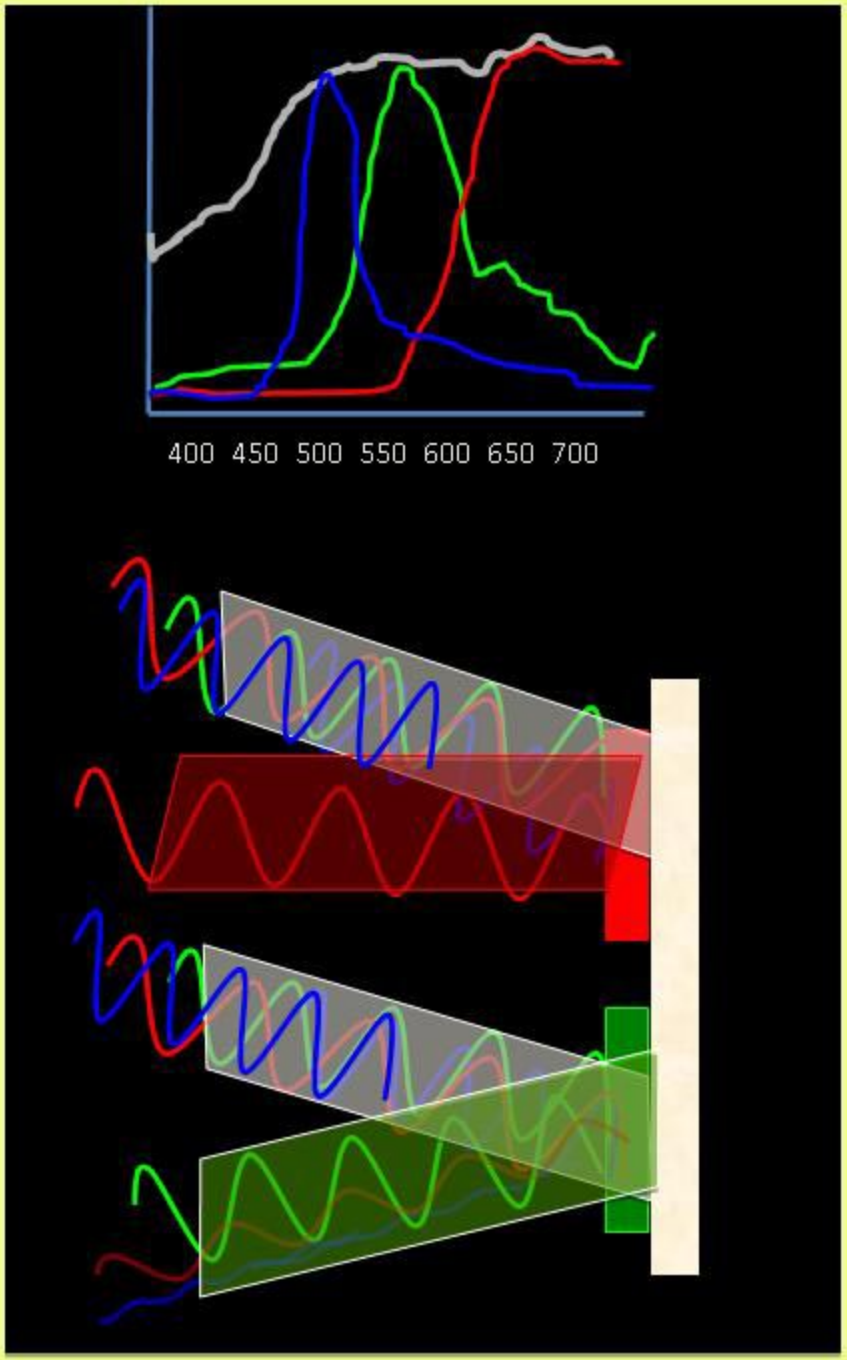


pigments

Ultramarine blue

Windsor Green

Cadmium Red



The trouble with purple

Two ways to get a reddish blue

Violet

Light at 460nm λ looks blue

440nm reddish blue (Violet)

The LW cone has a secondary peak in blue end

Short λ therefore activates both LW and SW cones.

Purple

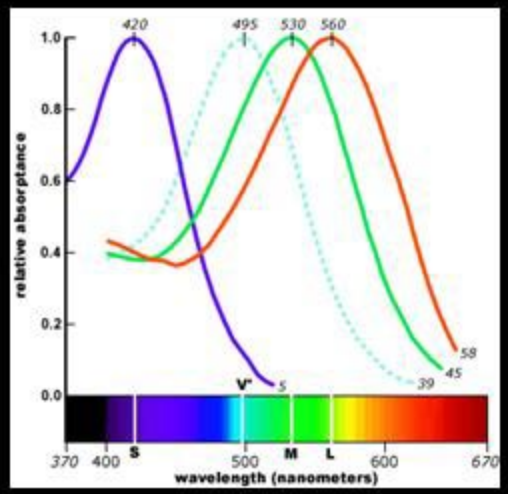
Cannot be generated by a single wavelenghth of light

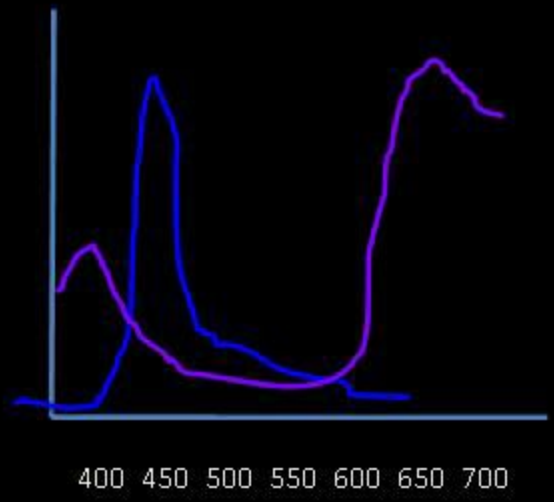
Can be made by mixing different colours

Purple objects reflect blue and red

They absorb specifically in a narrow range of λ green yellow

Such substances are rare and expensive





Ultramarine blue vs ultramarine violet

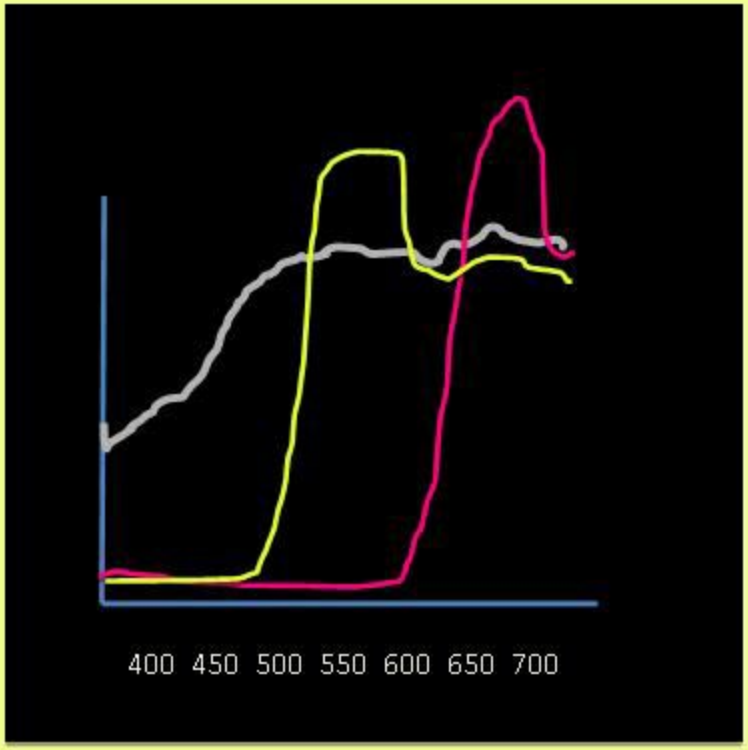
Non traditional colours

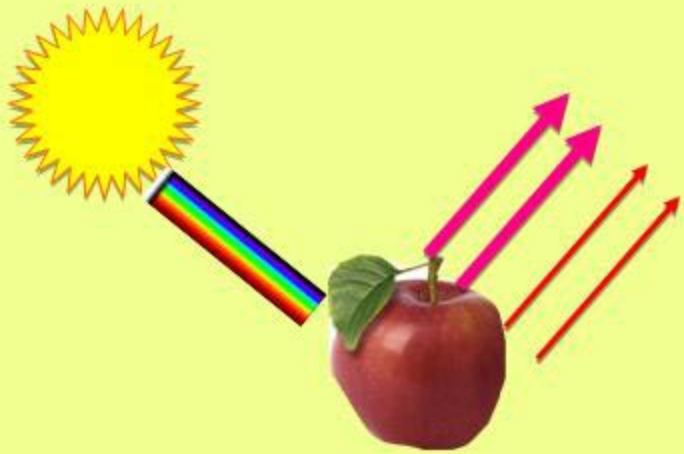
Fluorescent “dayGlo”

Absorb and re-emit at longer wavelength

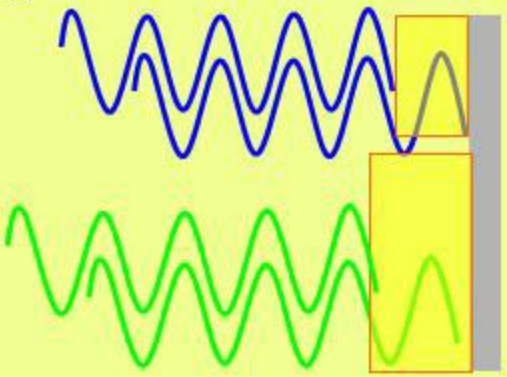
Conventional colour reflects a maximum of 90% of a colour present in the spectrum;

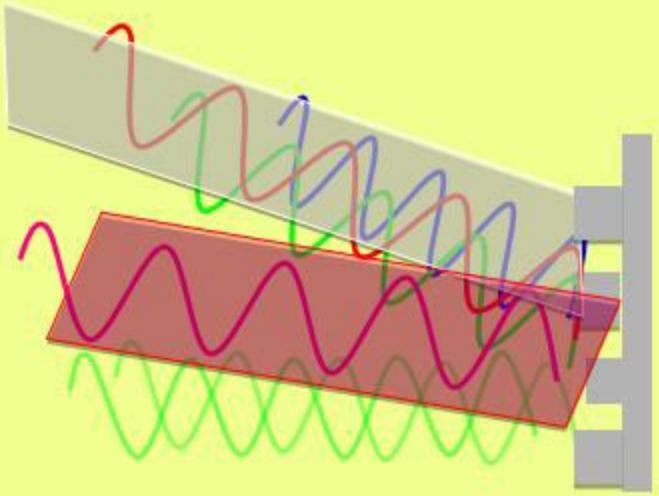
Fluorescent color can reflect up to 200% to 300%.





Other ways of generating colour





Structural colours

1665: *Micrographia*, Robert Hooke "fantastical" (structural, not pigment) colours of the Peacock's feathers

Butterfly wings

Beetles

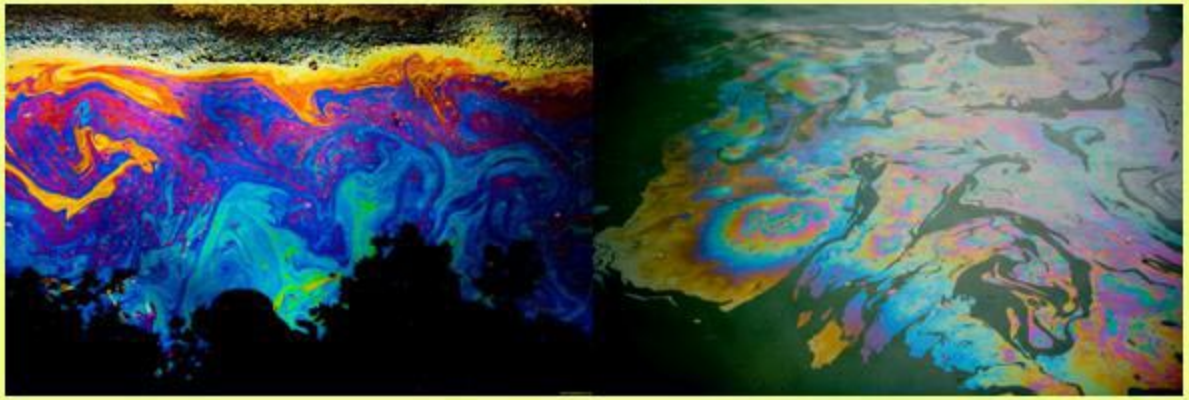
Oil slicks

1634: Sir Theodore de Mayerne, physician to Charles I, observed that the 'eyes' on the wings of the peacock butterfly "shine curiously like stars, and do cast about them sparks of the colour of the Rainbow

Some wavelengths reflected out of phase so cancel out

The complementary colour is seen

CD's



Damien Hirst
Butterflies

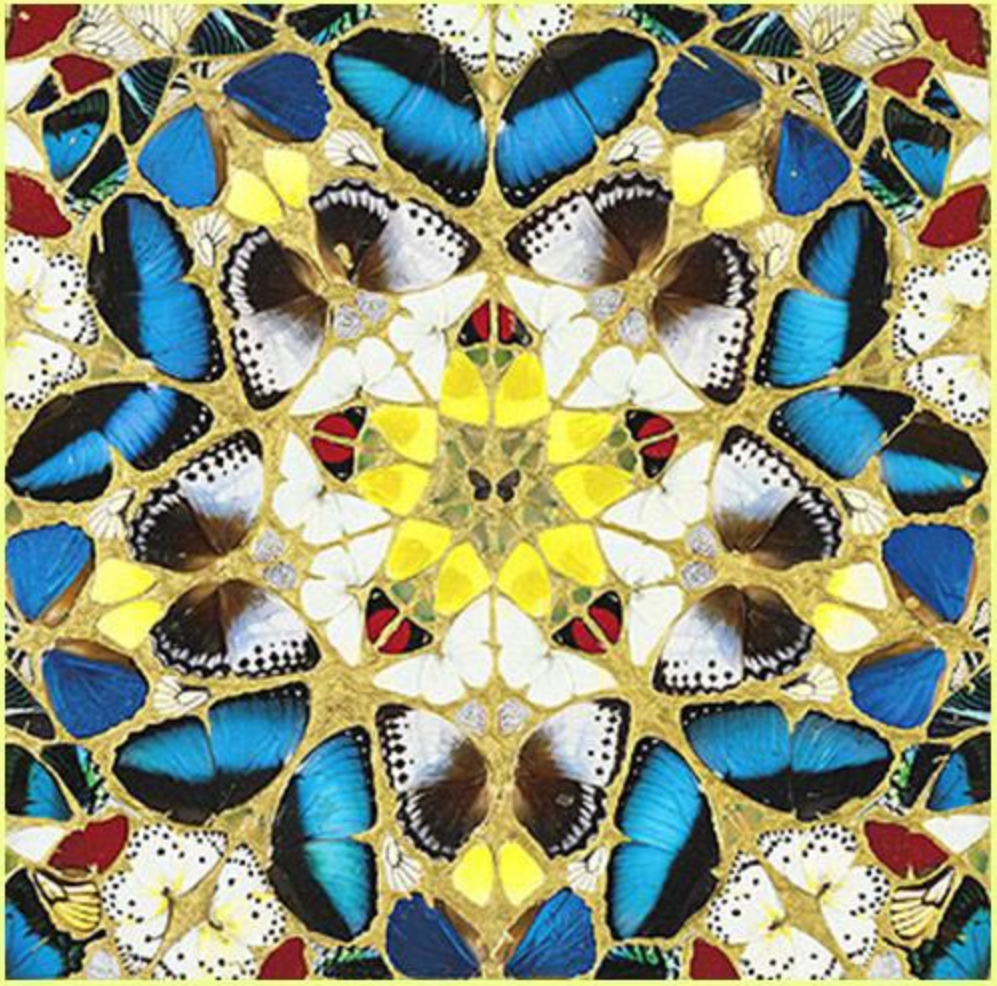
"I Am Become Death, Shatterer of Worlds" –

Hindu scripture the ***Bhagavad Gita*** quoted by J. Robert Oppenheimer after watching the test detonation of the first atomic bomb

"wanted to use real butterflies and not just pictures of butterflies, because I wanted it to shimmer when the light catches it like only real butterflies do."

Blue light has a wavelength range from 400 to 480 nm.

The slits in the scales of the Morpho are 200 nm apart half of the wavelength of blue, undergoes constructive interference.



Biology is interested in surfaces and the light reflected from them

React to local changes in light

Shadows

Edges

Movement

How far away

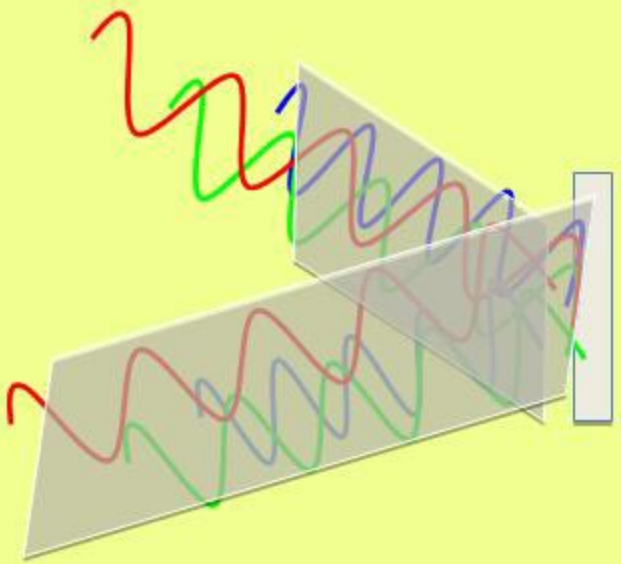
3D shape

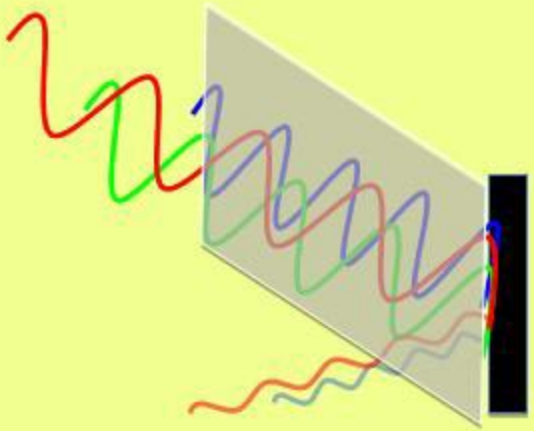
Object from background

Overall organisation of the visual scene

Object recognition

Colour





What is brown?

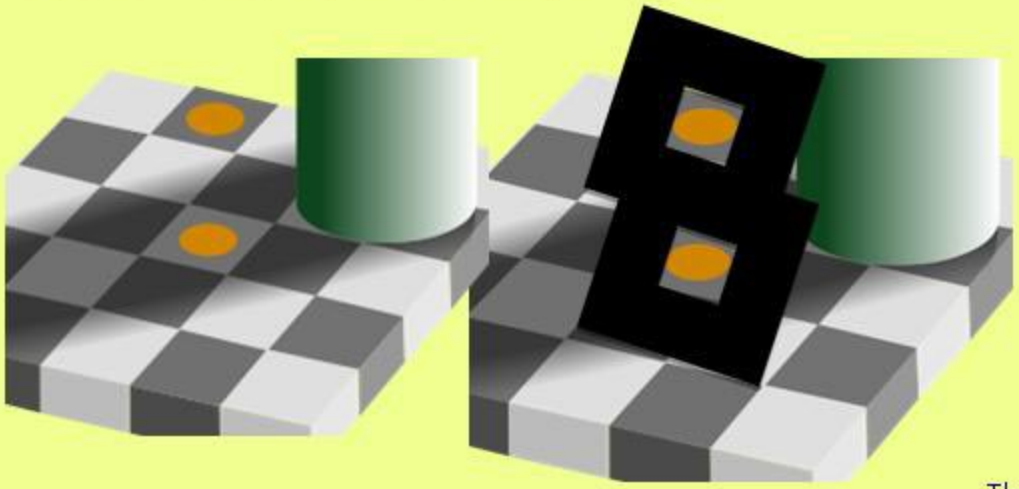
Brown is dark, low-chroma (desaturated), orange.

Orange light perceived in an environment that makes it look dark and less saturated appears brown.

A brighter surround is such an environment.

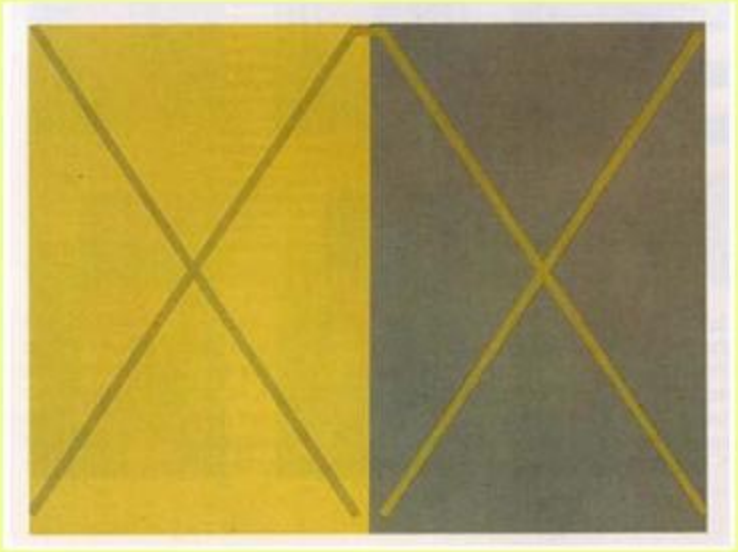
Brown is a special sort of colour perception that needs relationship to its environment to be perceived.

That's why you can't buy a brown light bulb!"



The brown and orange discs are identical, in identical gray surrounds,
Perceived colour categories depend on what white they are compared to

Non spectral colours:
Left: 250 units of red and 250 units of green.
right 50 units of red and 50 units of green.
olive is a very dark yellow.



The colour of a specific wavelength can change according to context. 'X' appears to be different when set against the two different backgrounds same spectral reflectance (Albers J. 1975).

Goethe *Zur Farbenlehre ("On Chromatics")*

Colour theory emphasizing antagonism between complementary colours, including light and dark.

Aristotelian and medieval optics colour results when light comingles with dark.

Sunlight the *"Urlicht"* or original light

Colours arise by the "shadowing" or darkening of homogeneous light; Cannot reassemble light from darkness; not seven; only two "primary" colors — yellow and blue — that emerge first from the light and dark mixture.

Goethe's view, Newton erred because he mistook a *secondary phenomenon for a primordial cause:*

Opticks (1704) contained both factual and moral errors; old nest of rats and owls" (Unmasking Newton's Theory)

Also accuses Newton of ignoring perception in favor of imaginary abstractions

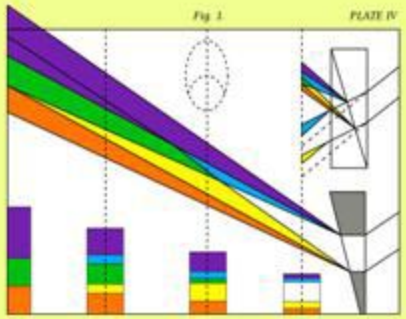
mathematics and physics *"a scientific coffin".*

Hoped to gain scientific support for the Aristotelian dogma.

Goethe correct: simultaneous contrast is a perceptual phenomenon: *"Every decided colour does a certain violence to the eye and forces it to opposition."*

Goethe, age 38,
Angelika Kauffmann 1787

1785: party in Weimar 1785, Goethe talks on his theory of primary colours with revolutionary Francisco de Miranda. Inspired flag of Gran Colombia,



Light spectrum, from *Theory of Colours*. Goethe observed that with a prism, colour arises at light-dark edges, and the spectrum occurs where these coloured edges overlap.

color as arising from the dynamic interplay of light and darkness through the mediation of a turbid medium

Turner

Colour used to take the place of form

Main colors used by Turner were red, yellow, and blue

Goethe's theory, the creation of color is dependent on the distribution of dark and light reflecting through a transparent object

Each colour a unique combination of light and dark

Yellow the first colour transmitted from light.

yellow undergoes a transition of light becoming darker when light reaches its peak, just as the sun shines in the sky, it develops to a white light that is colorless. But the light deepens and evolves the yellow into an orange and then finally to a ruby red

Turner illustrates the process of yellow transitioning into phases of light

The edges get darker.

Light and Colour (Goethe's Theory) – The Morning after the Deluge – Moses Writing the Book of Genesis

Three types of cones

extend the range of visible wavelengths;
also allow λ discrimination "colour vision"

L and M cones produce nearly all the information acquired by the retina

fovea has 50% of L and M cones in the retina

Dominant in colour vision.

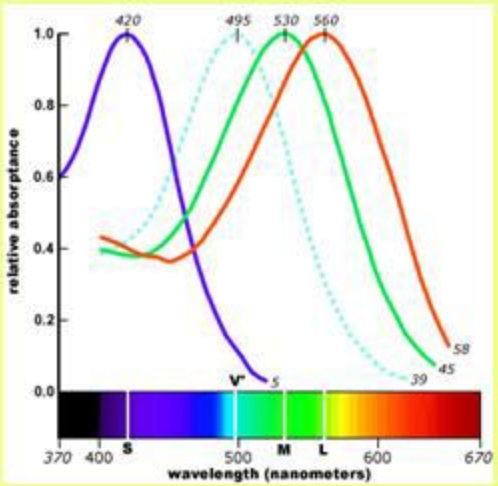
A single photon at a cone's peak sensitivity response equivalent to 10,000 or more photons at low sensitivity ends of the curve.

Eyes most sensitive to λ in middle of spectrum: yellows and greens are the most luminous colours in spectrum.

Sensitivities of L and M cones different red to yellow range

but similar through the "blue green" to "blue violet" parts of the spectrum.

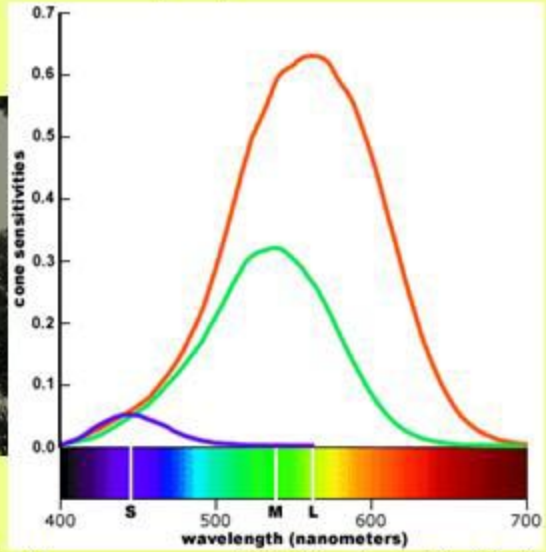
S cones break the tie in λ below ~525 nm



human photo-pigment absorption curves curves normalized to equal peak absorptance (1.0); number of photoreceptors measured at base of curve; Dartnall, Bowmaker & Mollon (1983)

photons	w/length	Response
100	650 red	+
200	650 red	++
100	625nm orange	+++

LW cone



population weighted linear cone sensitivity functions the Stockman & Sharpe (2000) 10° quantal cone fundamentals on a linear vertical scale, scaled to reflect L, M and S cone proportions in the retina (1.0 = total cumulative response by all three cones)

Trichromatic theory

ambiguity in the response of *individual* photoreceptors to light

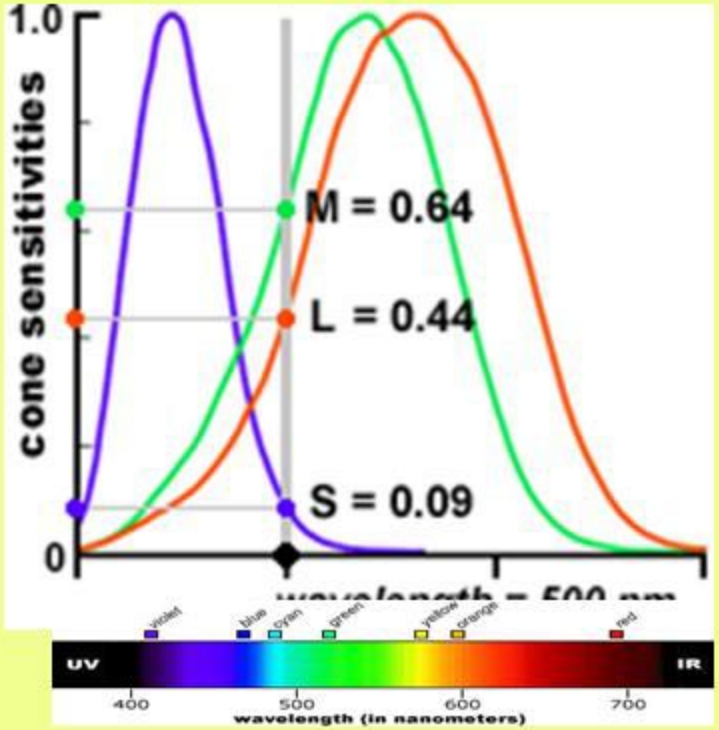
A single cone cannot distinguish changes in wavelength (hue) from changes in radiance (intensity).

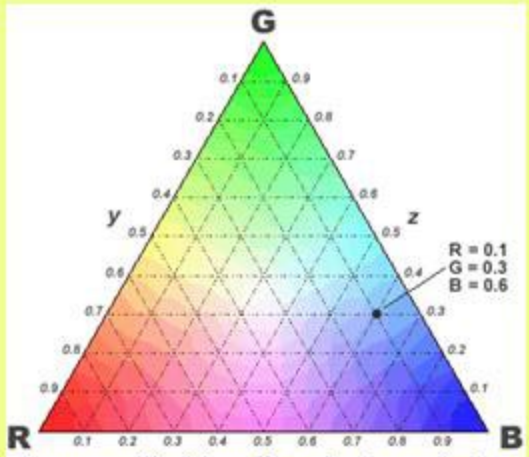
equally bright "green" and "red" λ,

Or a "green" λ bright and dim, produces identical change in the output of an L cone.

What cones cannot do individually they achieve together.

Colour defined by the combined response of all three cone types.





james clerk maxwell's "diagram of colours" (1857); the proportions of the additive primaries red, green, and blue violet (pigments vermilion, emerald green, and ultramarine blue) always add up to 1; the approximate location of cerulean blue is shown as an example

1850's quantitative study of stimulus and sensation: Psychophysics.

Weber (1795-1878), Gustav Fechner (1801-1887), Wilhelm Wundt (1832-1920),

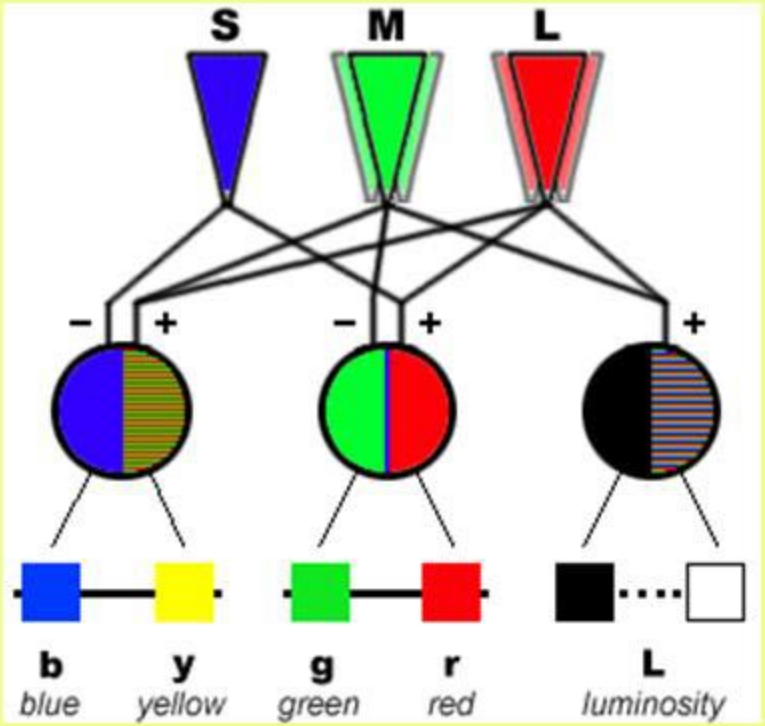
Ewald Hering (1834-1918)

1874: defense of subjective colour and antagonism, **Zur Lehre vom Lichtsinne** (On a Theory of the Light Sense)

perceptual primacy of four **Urfarben** or "primordial colors", red, yellow, green and blue. 470, 500, 570 and 700 nm

produced by visual substances or processes located somewhere in the visual system outside the retina.

organized as antagonistic or opponent processes.



Thalamic relay

When we look at lights or reflecting surfaces of objects, two of the features we notice are their colour and brightness

The chromatic channel subtractive mechanisms; **Small retinal ganglion cells** in Thalamus have receptive fields responsive to wavelength: Colour selective:

inhibited by other wavelengths

Type 1: Red, green and blue centre

Type 2: Colour opponent

Red on green off

Green on red off

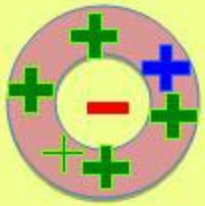
Blue on yellow off

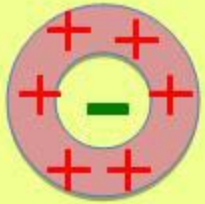
spectrally opponent channel.

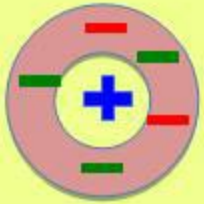
luminance channel is via the **magnocellular pathways**

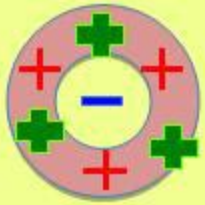
Type 3 cells colour blind

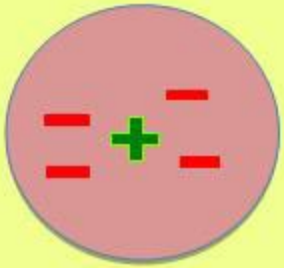
Respond to change in local light

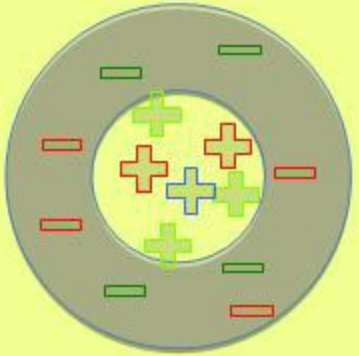


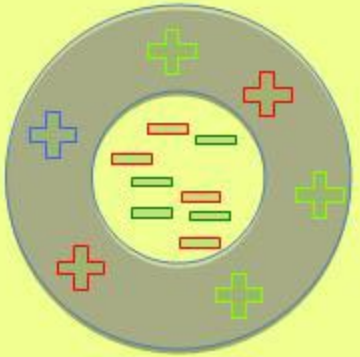












M-cells

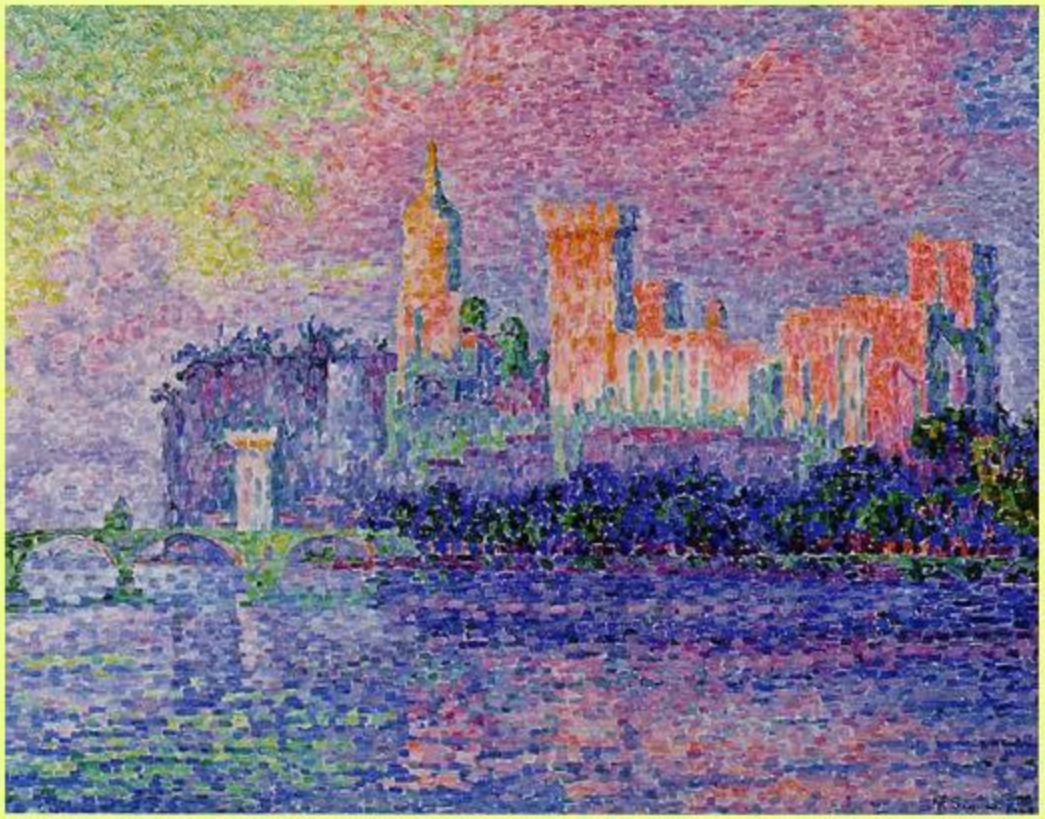
George Seurat

The colours of green and violet are in fact almost complementary and would if mixed as pigments produced a drab and dirty hue

Juxtaposed they produce a fine pearly grey"

They claimed the vibrancy was due to "optical mixing" The simultaneous viewing of adjacent patches of paint of different colours.

Margaret Livingstone argues that this cannot be the case



The Papal Palace, Avignon.
1900, George Seurat. Musée d'Orsay.

Luminance and Colour

Madame Paul-Sigisbert Moitessier, , Seated 1856; Jean Auguste Dominique Ingres
National Gallery

Perfect treatment of luminance: Photographic quality

Gulf racing,

Steve McQueen, the Ford GT, the Porsche 917, “Cool”

Grady Davis, Executive V.P. of Gulf, when Gulf became the sponsor of the J.W. Automotive team of GT.40s.

Specified powder blue and orange, corporate colors of the Wilshire Oil Company, from California.

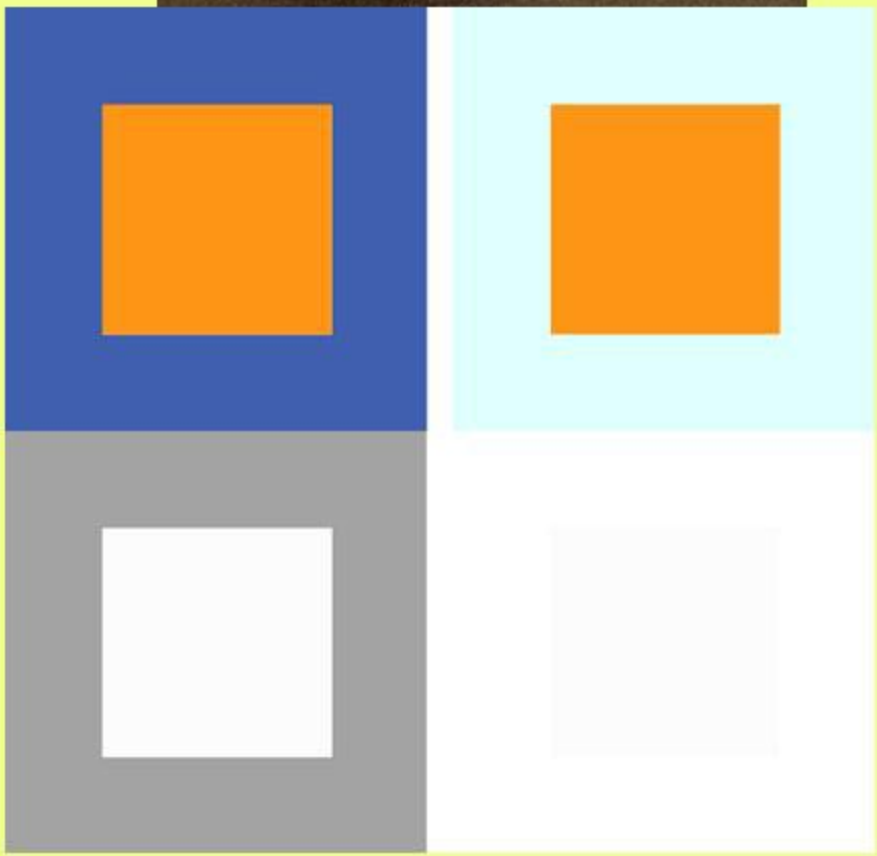
Complimentary on the color wheel, the powder blue is of a lighter value than the orange.

the colours they chose had more optical vibrancy than the darker navy blue used in the corporate logo.

phenomenon is called “Equiluminant Colors”.

When our eyes encounter colors that are Equiluminant, we have a hard time assigning them positions, so the color tends to vibrate or move slightly

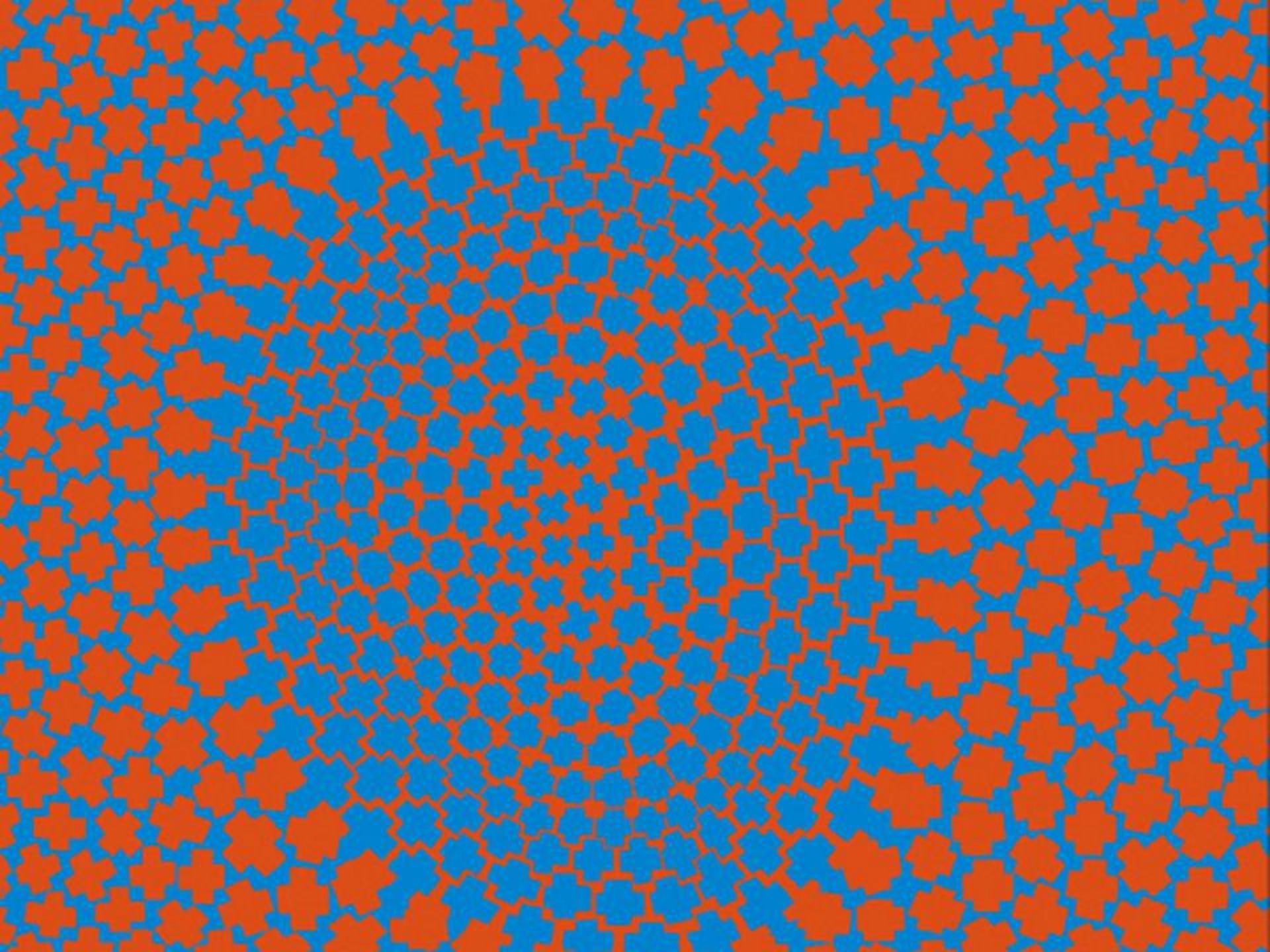
Wadejohnston1962 Kansas City

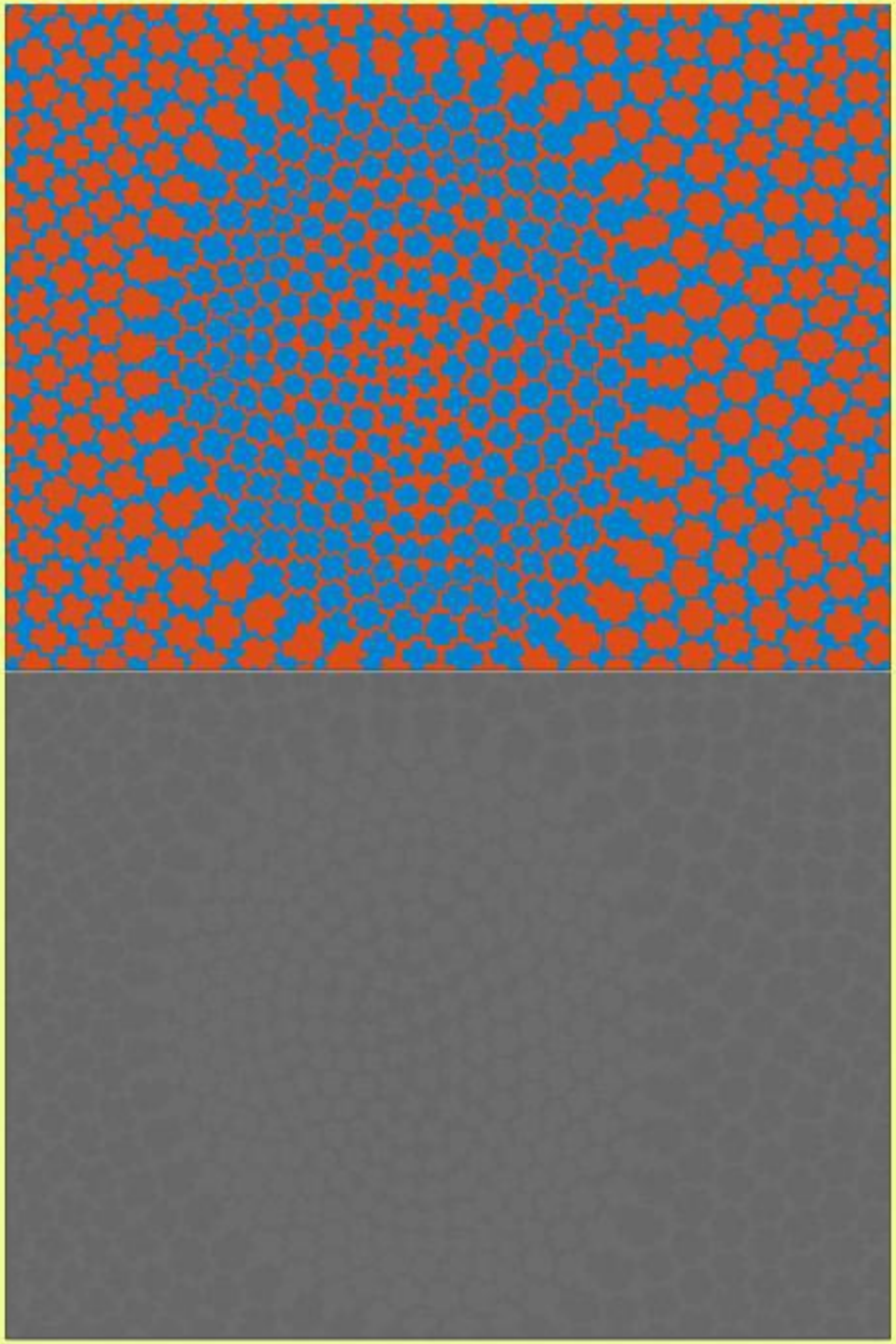


Luminance

Reflected light from window appears brighter than the reality of the light the pigment reflects

St Paul at his Writing-Desk; **1629**
Germanisches Nationalmuseum



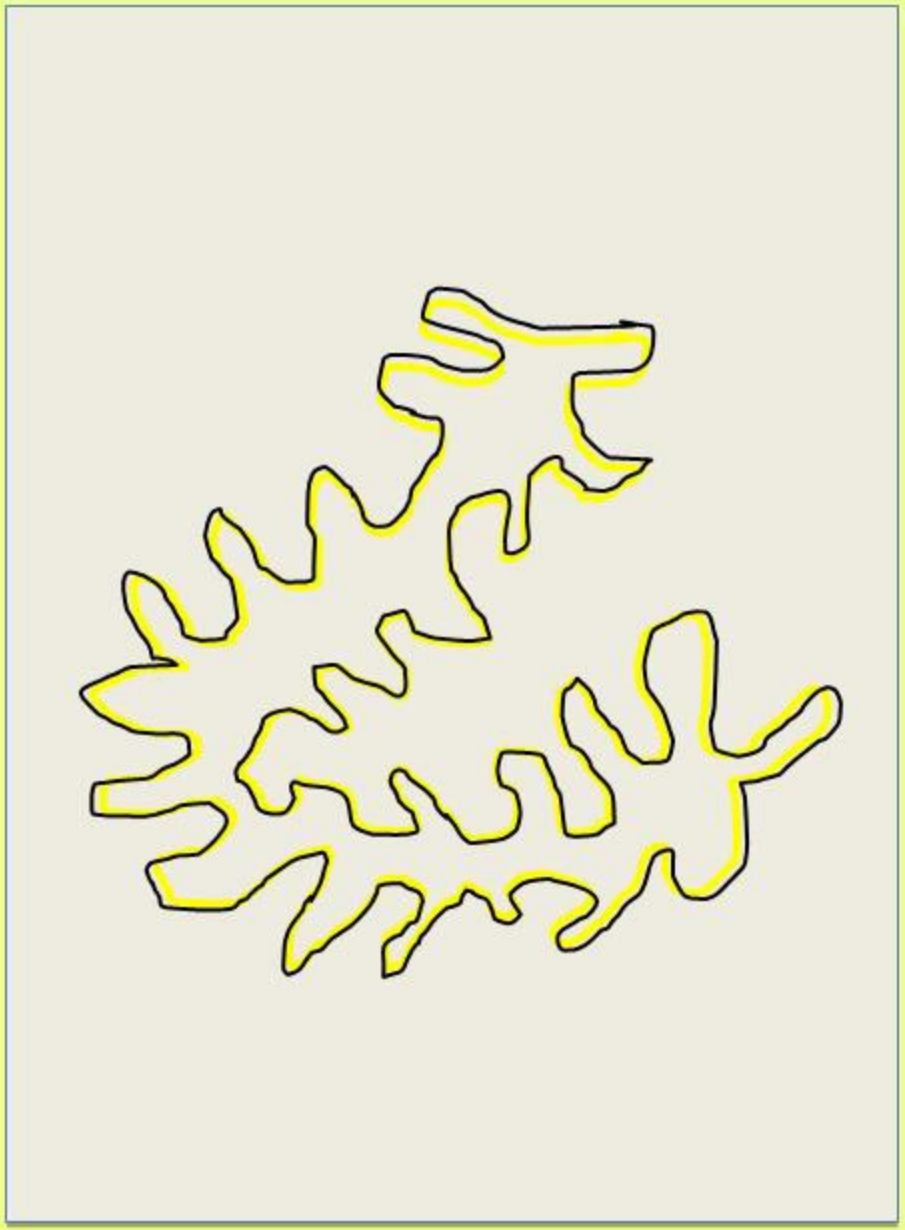


Richard Anusziewicz
"Plus Reversed"

Colour system responds to borders

No neural activity in centre of object

That is filled in perceptually.



Water colour illusion

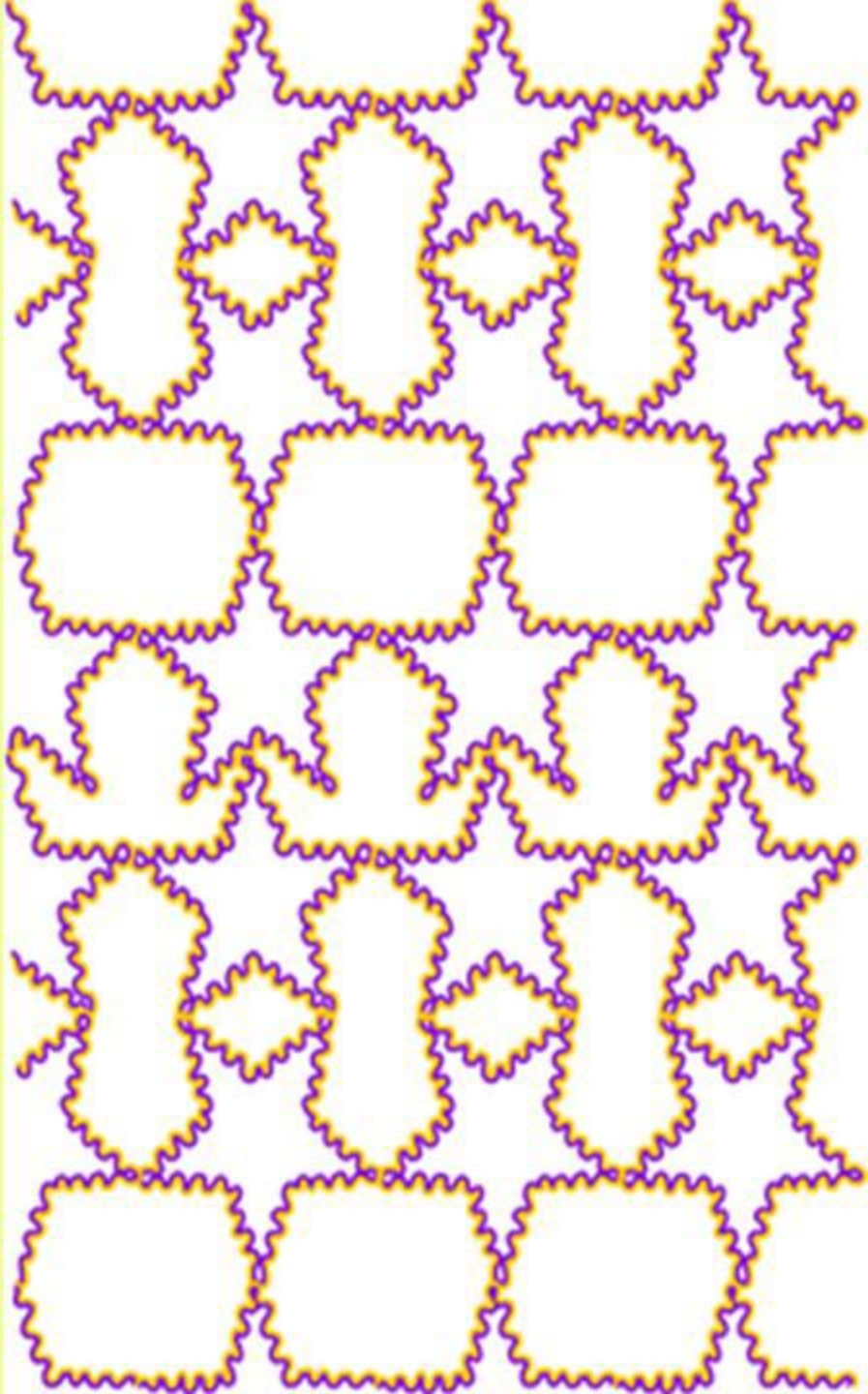
The separation between the colour and figure effects indicates parallel but related processes.

Boundary and surface features are treated differently by the information streams of the visual system.

Firstly deciding what is the boundary of an object seen by each eye, then using this to fill in the surface colour, texture, etc.

More cells in V2 than V1 are excited by the Kanizsa-square. Neurons in V2 respond with different strength to the same contrast border, depending on the side of the figure to which the border belongs.

the colour tint of the watercolor illusion also explained by cortical representation of borders (von der Heydt & Pierson, 2006).



The primary visual cortex fills in color

Spreading effect of colour inclusions in repetitive structures like a neon tube.

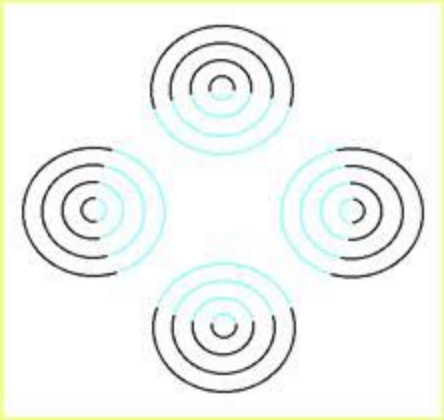
luminescent colour appears to fill the empty spaces in between lines.

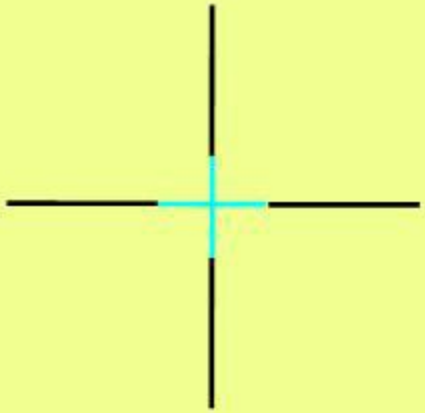
the illusion of a semi-transparent structure is created at the front.

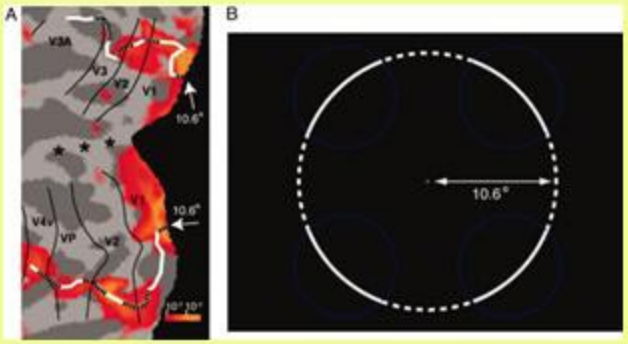
Even if the light of the inlays is insufficient to be perceived, our eyes - which were developed some 300 million years ago - may still be able to discern something thanks to this heightening of perception.

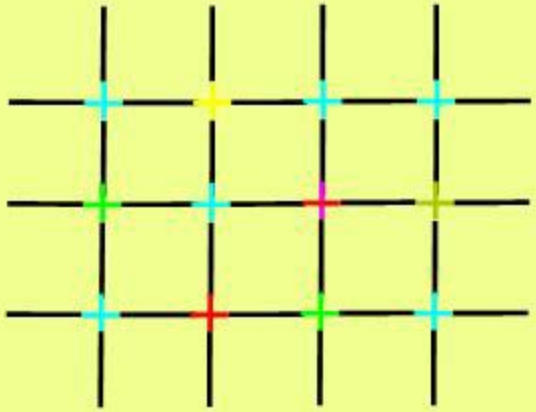
Complex effect must either be an anomaly of human evolution or have a deeper meaning.

might be a remnant of the development of sight under water: perception of transparent bodies located in front of filigree structures may have played a role.









Varin D, 1971Fenomeni di contrasto e diffusione cromatica nell`organizzazione spaziale del campo percettivoRivista di Psicologia 65 101-128[2]

van Tujil, H. (1975)A new visual illusion: Neonlike color spreading and complementary color induction between subjective contours.Acta Psychologica, 39, 441-445.

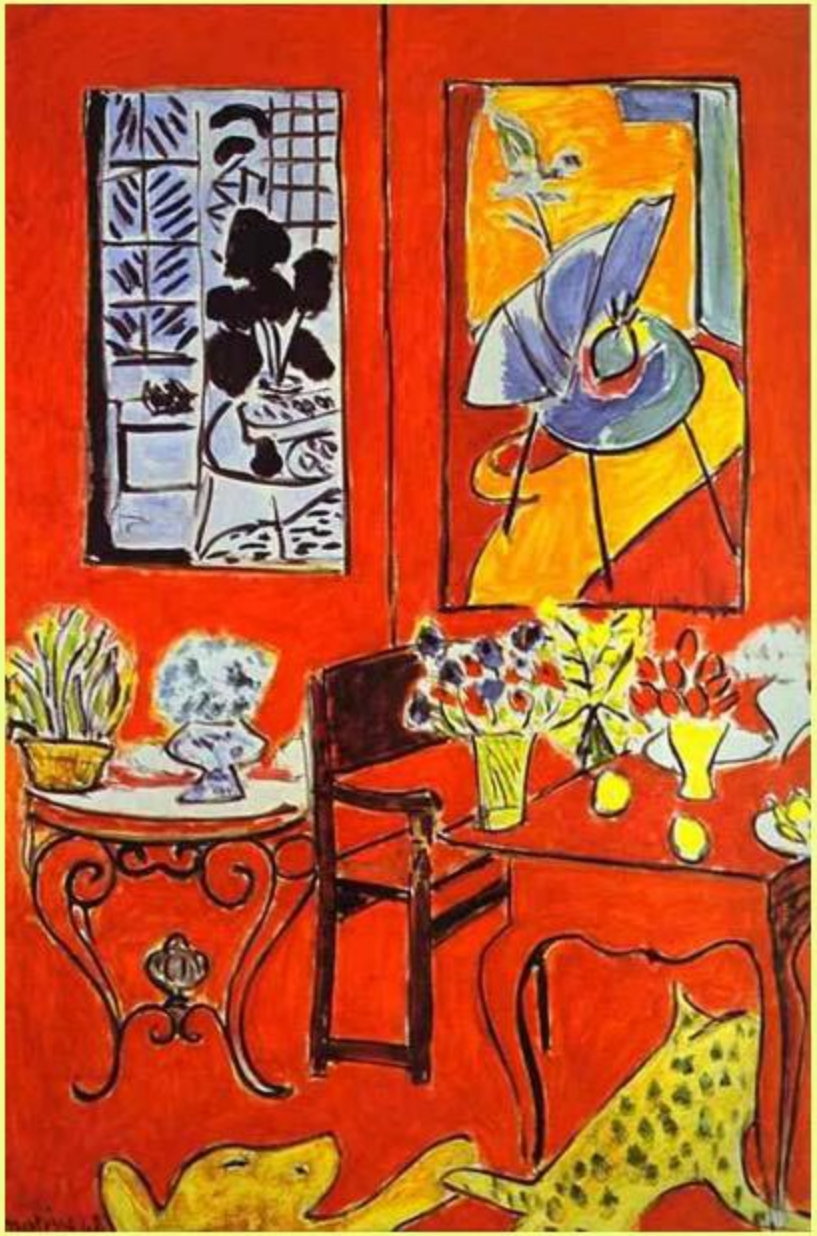
: Yuka Sasaki and Takeo Watanabe

Role of what system

Colour part of the what system has large receptive fields

Low resolution

Matisse small rumanian blouse



Henri Matisse. *Large Red Interior. 1848*

Matisse

1905, exhibited with Albert Marquet, Maurice de Vlaminck, Kees van Dongen, Charles Camoin, and Jean Puy in a room at the Salon d'Automne containing a renaissance statue.

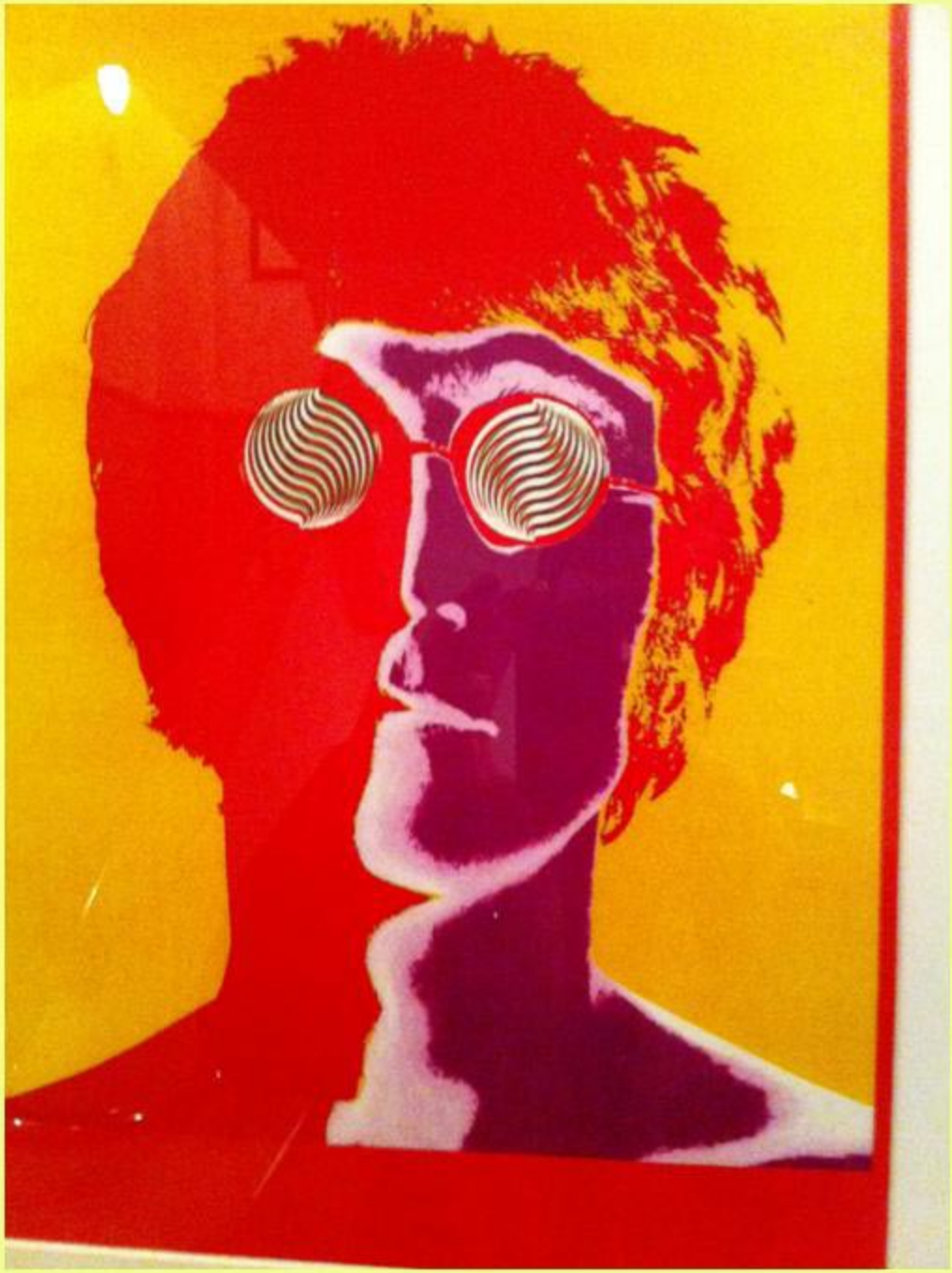
clashing hues, not related to subject's natural colours.

Matisse showed Open Window and Woman with the Hat

Critic **Louis Vauxcelles** described the work with the phrase ***"Donatello parmi les fauves!" (wild beasts)***

Matisse discovered that he could use any hue as long as the luminance was appropriate

Despite the unrealistic colours the shape of the face looks fine, because the luminances are appropriate.

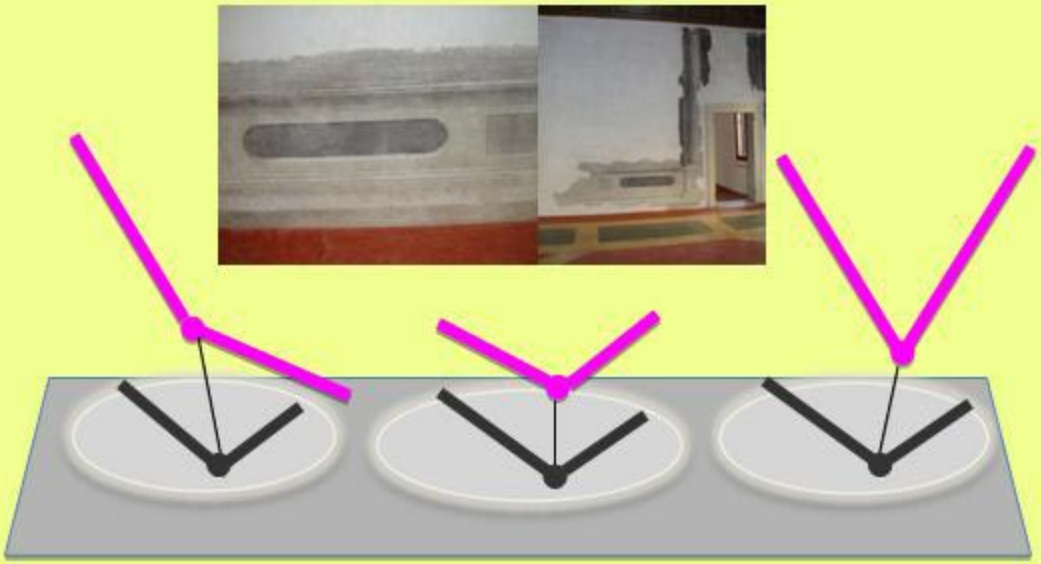


Analysis of depth
Analysis of distance

light rays do not tell us how far they have travelled; so how can we determine depth or distance from whence they came?

Images are flat but contain lots of information about depth.

- Perspective: shape on the retina is ambiguous. Perspective can suggest 3D if we make assumptions
- Texture gradients: Cells in parietal lobe
- Shape from shading: Only works if we know where light source is. Assumption from above. Cells in V4 respond to shadow below. Rotate 90^0 no response
- Interruption of lines (occlusion). Tilted line detectors in V1
- Upward sloping ground
- Size constancy: Psychologically expand perception of the smaller image of a distant object.
- Atmospheric perspective



Identical 2D shadows can be generated by completely different 3D objects
We cannot reconstruct the original object on the basis of the image alone. We could make a guess if we knew the angle of the lighting. More accurate prediction based on likelihood of which shape, acute or obtuse, in which context

A Philosopher Giving that Lecture on the Orrery, (1766) by Joseph Wright of Derby

a public lecture about a model solar system: The Orrery Lamp is put in place of the Sun, the partially illuminated faces represent the phases of the moon, full (the children) to gibbous (left) to new (man seen from behind)

Other traditions

China

- Mo Ti or Mozi 5thC BC. Engineer founded school of thought , Mohism, flourished during the Warring States era (479-221 BC). Understood principles of pin hole camera.
- Shen Kuo (1031-1095 AD) *Mengxi bitan Dream Pool Essays* of 1088, Shen Kuo experimented with the camera obscura
- Zhāng Zé duān 张择端 (1085-1145 AD): Painting of daily life of the Song Dynasty capital Kaifeng geometrically accurate. Techniques: shading and foreshortening, later abandoned and not developed further.
- 1606: Christian convert Xu Guang-qi translates Euclid's elements
- 1617 Emperor Wanli evicts Jesuits

Size constancy

Information about distance is derived from various cues convergence of the eyes,

geometrical perspective (many illusion figures having converging lines), and the

graded texture and falling of sharpness ('aerial perspective').

Any cue to distance can set the compensatory size-scaling mechanism

when mis-set causes size or shape distortion illusion

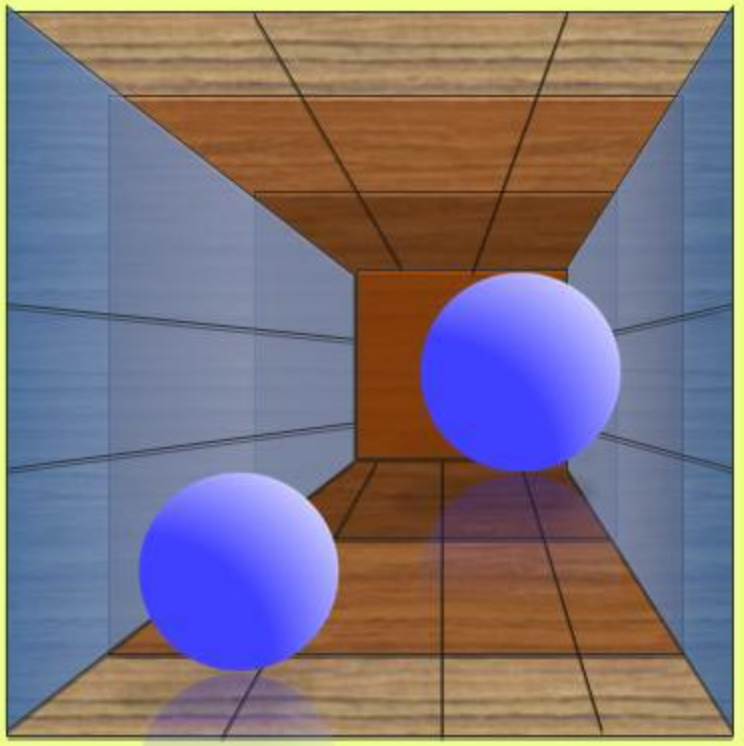
The further ball appears to be bigger.

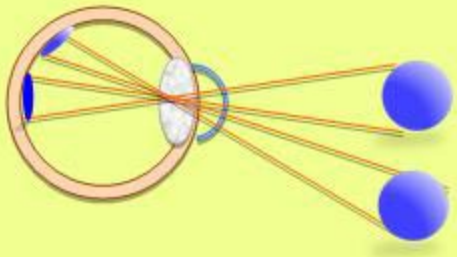
Is this a failing of the visual system?

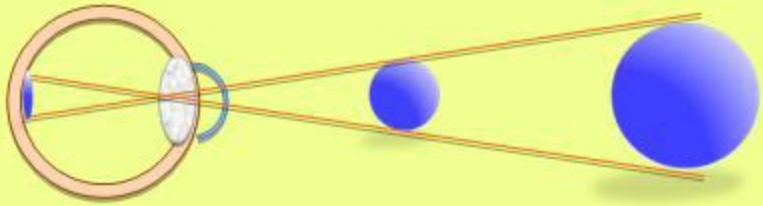
visual system versatile enough to tell us about real size not retinal size.

In the real world the top ball would be further away. It has the same retinal image size so therefore must be bigger.

The 2 balls subtend the exact same angle but are perceived to be at different distances. The brain therefore tells us (generates a percept) that the upper ball is larger.







Analysis of distance

Motion parallax

Not always a good thing to bring attention to oneself

Brain has some purpose built analogue computers to judge range.

Binocular parallax

Compares the 2 images from each eye.

A shift of only a few 1,000ths of a mm changes light on a cone by ~5%. This causes it to fire. Upstream individual cells which have receptive fields in slightly different places can detect depth.

Random dot stereogram: Centre dots moved slightly in one eye's image.

Neighbouring points are same distance but now have no correlation in brightness

Enables the parallax computers in the brain to find them. They have large receptive fields to make job easier, average light over large areas.

Useful to detect moths on bark

Stereopsis

3D

Despite perspective

Makes us not believe picture

Depth perception

3D objects reflect different amounts of light

Changes in luminance (shading)

Depth cue

Luminance contrast is enough to give a very vivid impression of depth.

Colour blind channel

Shape from shading

Orientation of objects

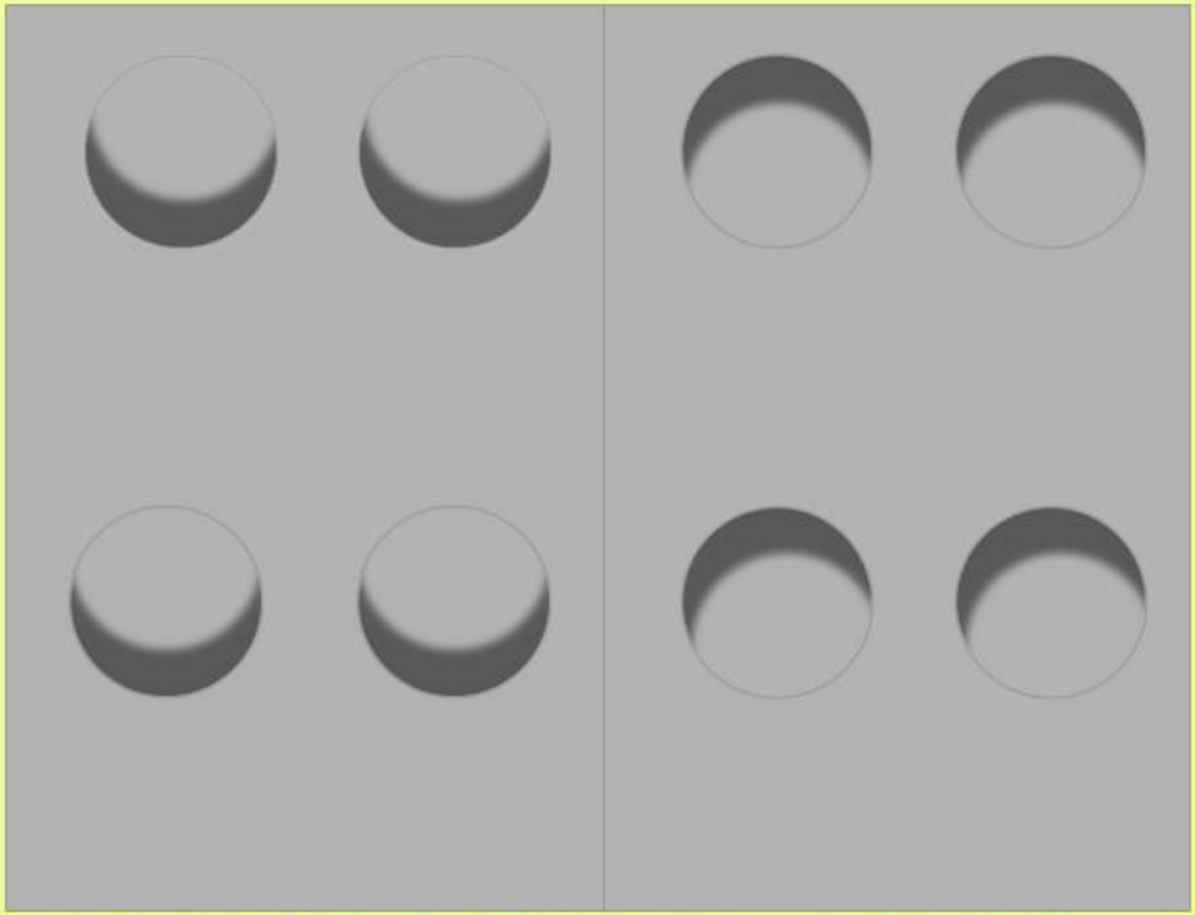
1.To guide movements. Learns quickly (inverted prism experiment, learned to ride bike)

2.To interpret the shape of objects and the orientation with respect to gravity

Learns slowly.

Difficult to recognise upside down faces.

Two circuits in the brain. One wired to control of movement the other wired to recognition of shapes (and faces)



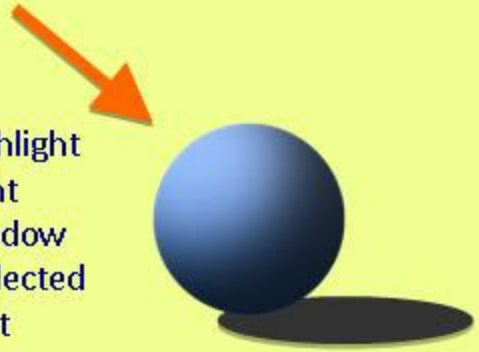
Our visual systems evolved with one major source of light and that came from the sky above.
Simple inversion of shaded images can dramatically change our perception of the object.
Buttons become dimples

Painting depth

Chiaroscuro
light and shade

Modeling of volume by depicting light and shade and their contrast.

Strengthens an illusion of depth on a 2 D surface. Important topic in Renaissance.



The Rest on the Flight into Egypt 1510 Gerard David

Camouflage

The brain has to interpret the patterns formed by images in eye. Thus needs to distinguish objects from their background. Fooling this system is how camouflage works.

India 1848. Khaki-colored uniforms: Dust coloured. Used officially by British army during Abyssinian campaign 1867-68, Indian troops sent to Ethiopia under general Sir Robert Napier to release British captives from King Theodore.

Abbott Handerson Thayer, American painter. Pioneer of modern camouflage. 1892, "The Meaning of the White Undersides of Animals."; counter-shaded. impression of 3D.

Gertrude Stein: *The Autobiography of Alice B. Toklas.* WW1, walking with Pablo Picasso on Bvd Raspail, "All of a sudden down the street came some big cannon, the first any of us had seen painted, that is camouflaged. Pablo stopped, he was spellbound. 'C'est nous qui avons fait ca,'

Norman Wilkinson British artist 1917: U-boat threat: a ship cannot be hidden, so prevent it from being hit. Recommended ships painted in high contrast, asymmetric shapes, *dazzle painting*

Used on speed trap cameras to fool which way pointing Austria.

Roy R. Behrens

Dazzle-ships in Dry-dock at Liverpool, Edward Wadsworth, 1919

Bacon c1220-1292

Visual realism.

Images of saints were to stimulate thought of the deeds.

Icons Not realistic.

religion should be represented as realistically as possible.

Perspectival drawing gives a 3-D realism, bringing saints to life on church walls.

New Basilica of St. Francis, at Assisi, perspective paintings.

The most popular tourist attractions of its age.

150yrs before Bruneleschi in Florence

Perspective

Rendering a three-dimensional world onto two dimensions

C14th , Alhazen's *Book of Optics* Italian translation, Deli Aspecti.

Quoted by Lorenzo Ghiberti: Bronze doors of Baptistry

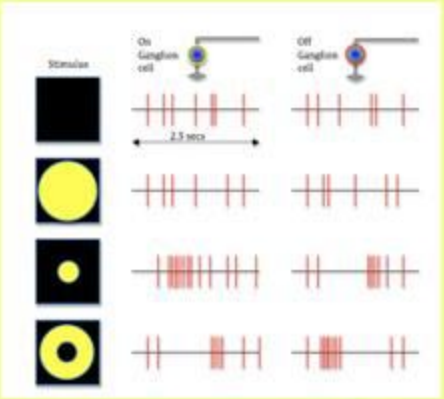
Linear perspective, Brunelleschi 1413.

Brunelleschi is famous for two panel paintings illustrating geometric optical linear perspective made in the early 1400s

Giotto and Lorenzetti a century earlier

Ambrogio Lorenzetti annunciation-1344

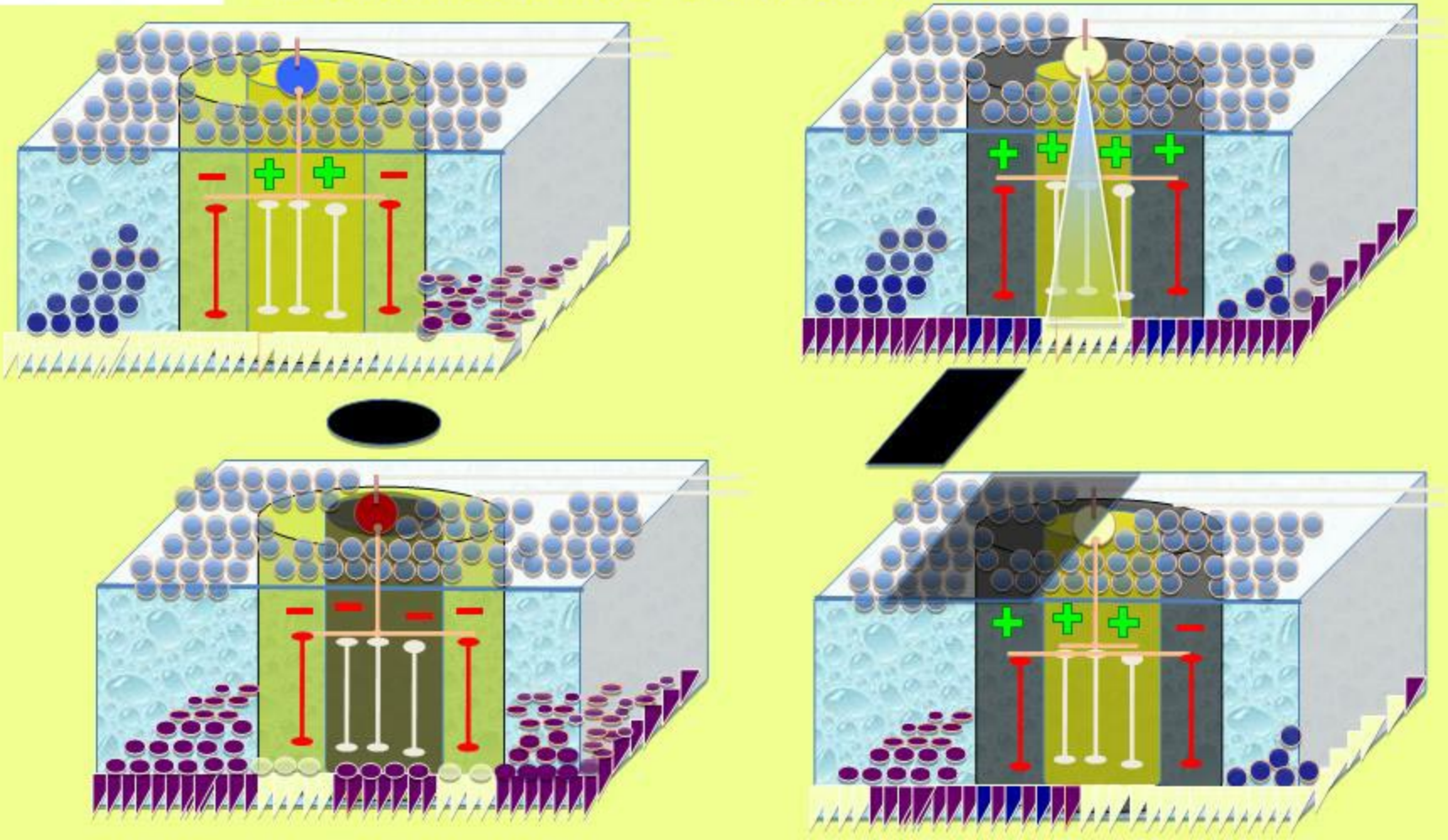
Pinacoteca Nazionale, Siena



Intensity of light gives sensation of relative lightness and darkness
The sensation of brightness is not proportional to intensity of the light!

VISION: information processing not image transmission

Retinal Ganglion cells perform calculations on the signals generated by photoreceptors.
An on-center cell: increase rate with small spot shone in the center of the receptive field.
An *off-center* cell: does the opposite: a surround that gave on responses.
In nature, dark objects are as common as light ones.
Sensitive to discontinuities in pattern of light.
Only encodes those parts of scene where there are changes (JPEG)



Illusions of depth in art

trompe l'oeil

occur in the paintings of architectural elements that surround the frescos in Medieval churches.

Masacchio: the Trinity, Fresco

Dominican church of Santa Maria Novella.

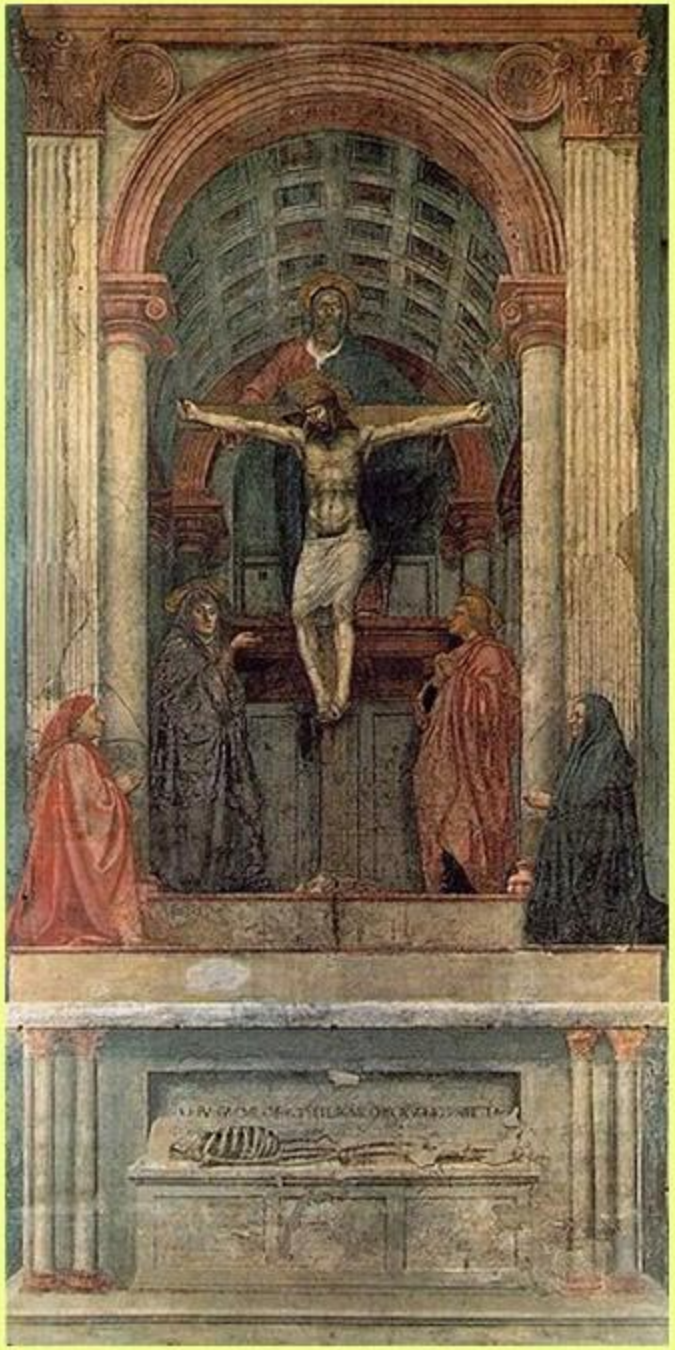
Hidden by Vasari's renovations commissioned by Cosimo I duke of Florence

rediscovered when Vasari's altar was dismantled during renovations in 1860

illusion of a barrel vault ceiling behind the figure of God

the wall behind the work seem to disappear so that the painting becomes an extension of the space we are in.

Died 1428 aged 26



Perspective

Canaletto

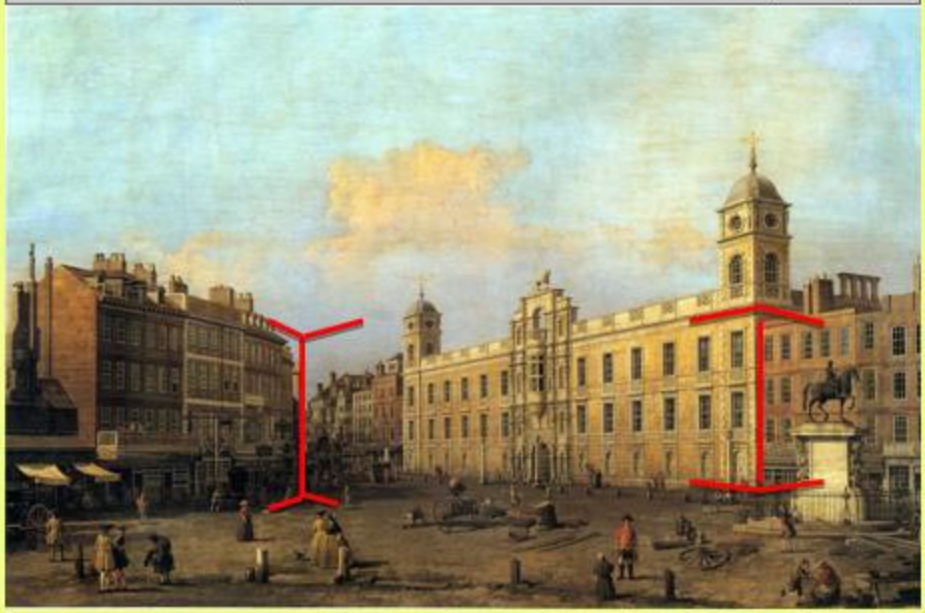
visual processes which judge depth and distance assume that the arrow point configuration corresponds to a closer object and the fletch configuration corresponds to an object which is far away.

The ambiguity solving mechanisms assumes these configurations are 90° angles; speeds up the interpretation, but gives rise to optical illusions in new situations.

Franz. Müller-Lyer 1889

By drawing lines that all slope up or down from corners, people get the impression of depth. Paintings use this to make illusion of perspective.

Northumberland House by Canaletto in 1752. Site of St Mary's Rouncivall Hospital. The lion is the emblem of the Percy family



Two streams for visual processing: "where/what" or "action/perception"

Where pathway: spatial processing: **parietal lobe**.

perception and interpretation of spatial relationships

space, position,

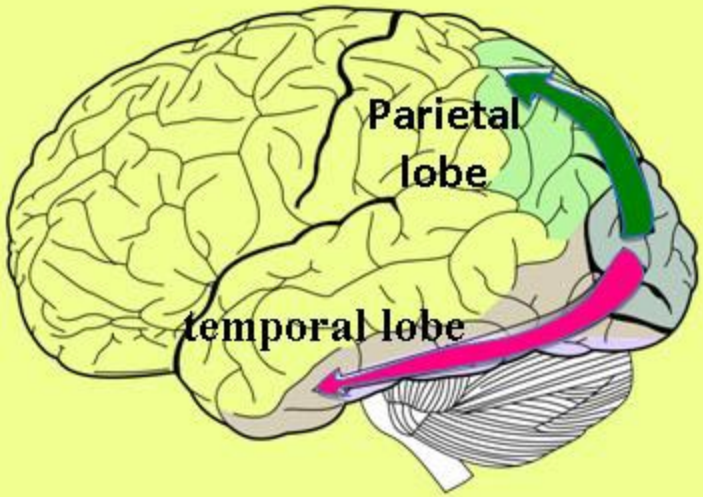
depth 3D,

figure ground

motion

overall organisation of the visual scene.

accurate body image, and the learning of tasks involving coordination of the body in space



What pathway: Well developed in primates: temporal lobe.

Object identification, in detail and colour;

recognising faces

Interacts with attention and memory.

Assesses significance of objects

A controversial simplification: Ungerleider and Mishkin

Analysis of motion

Photos and paintings cannot represent movement

We don't see blur in moving objects. We also don't see a series of frozen snapshots

The sense of movement is specific like smell.

Motion is computed directly from the retinal image

Motion detectors

Movement detector:

Present in retina of rabbit

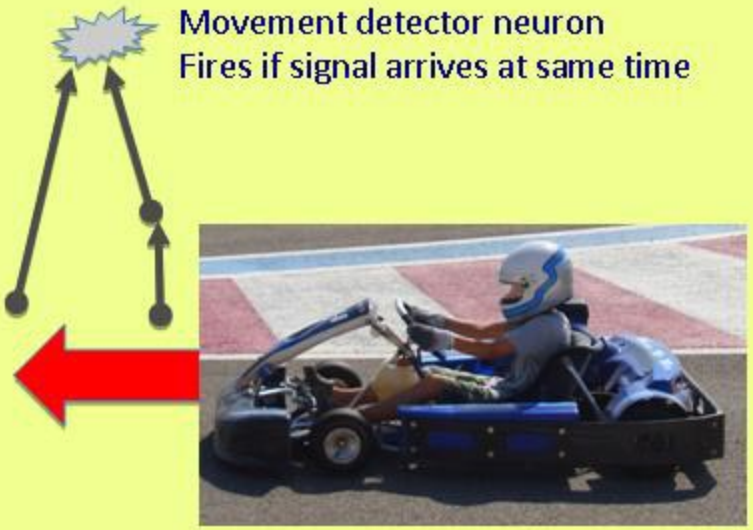
Brain of monkeys

Some of the parallax detectors also respond to differences of movement between the 2 eyes. Effect of object moving in third dimension. (pendulum)

Keinoscope

Cartoon

cinema



Movement

Giacomo Balla: Futurist painter and teacher, movement, which they saw as symbolic of their commitment to the dynamic forward thrust of the twentieth century.

1909 he interested in depiction of light, movement and speed as outlined by the Futurists primary objective to depict

1912 to early 1913 Giacomo Balla turned from a depiction of the splintering of light to the exploration of movement and, more specifically, the speed of racing automobiles

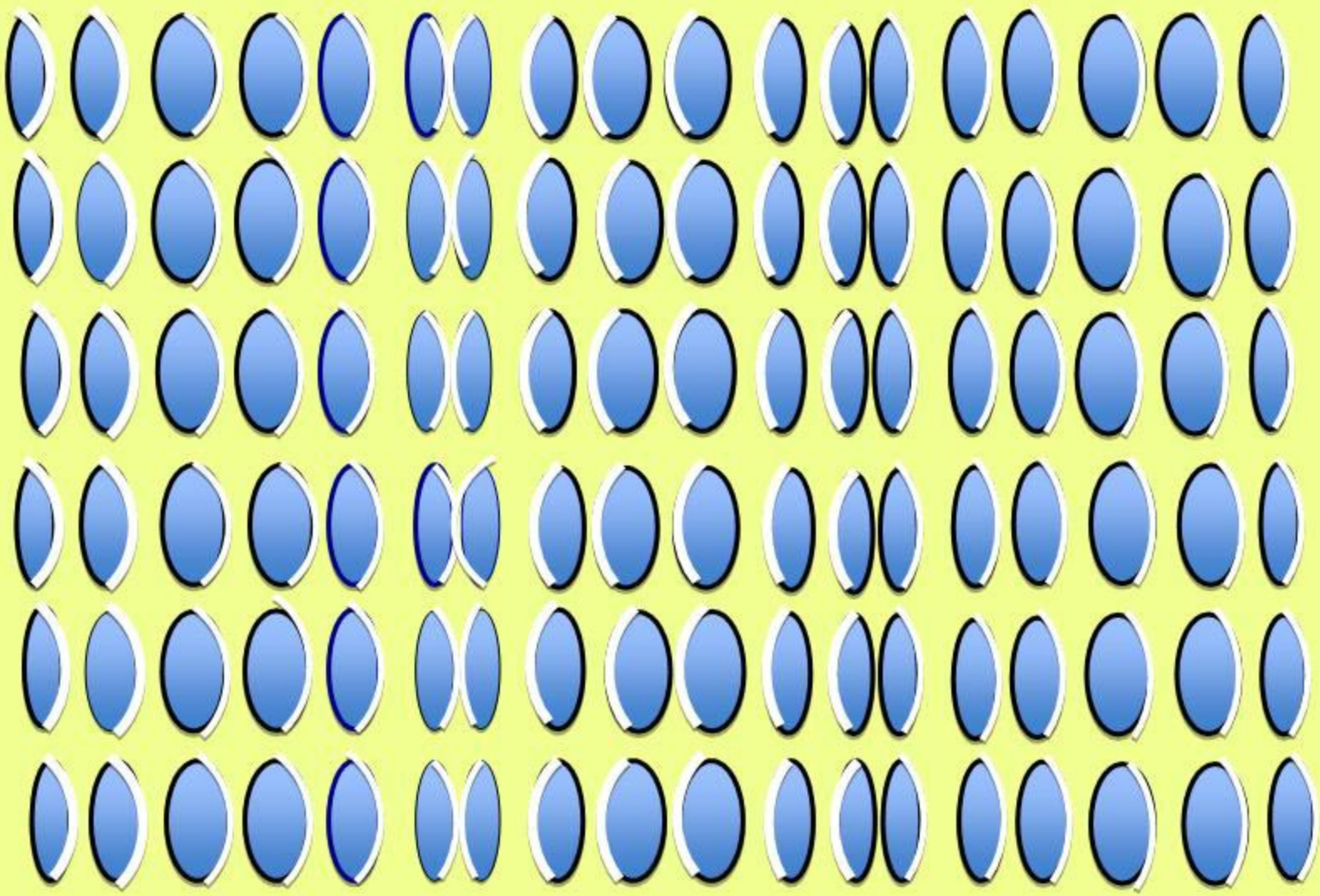
suggesting the alteration of landscape by the passage of a car through the atmosphere

crisscross motifs, representing sound, and a multiplication of the number of lines and planes.

Dynamism of a dog on a leash Giacomo Balla 1912
Knox Gallery Buffalo NY

Abstract Speed and Sound, Velocità Astratta e Rumore, 1913-14 Oil on Board Guggenheim

Chauvet Cave contains the oldest paintings on record (some of them 32,000 years old)



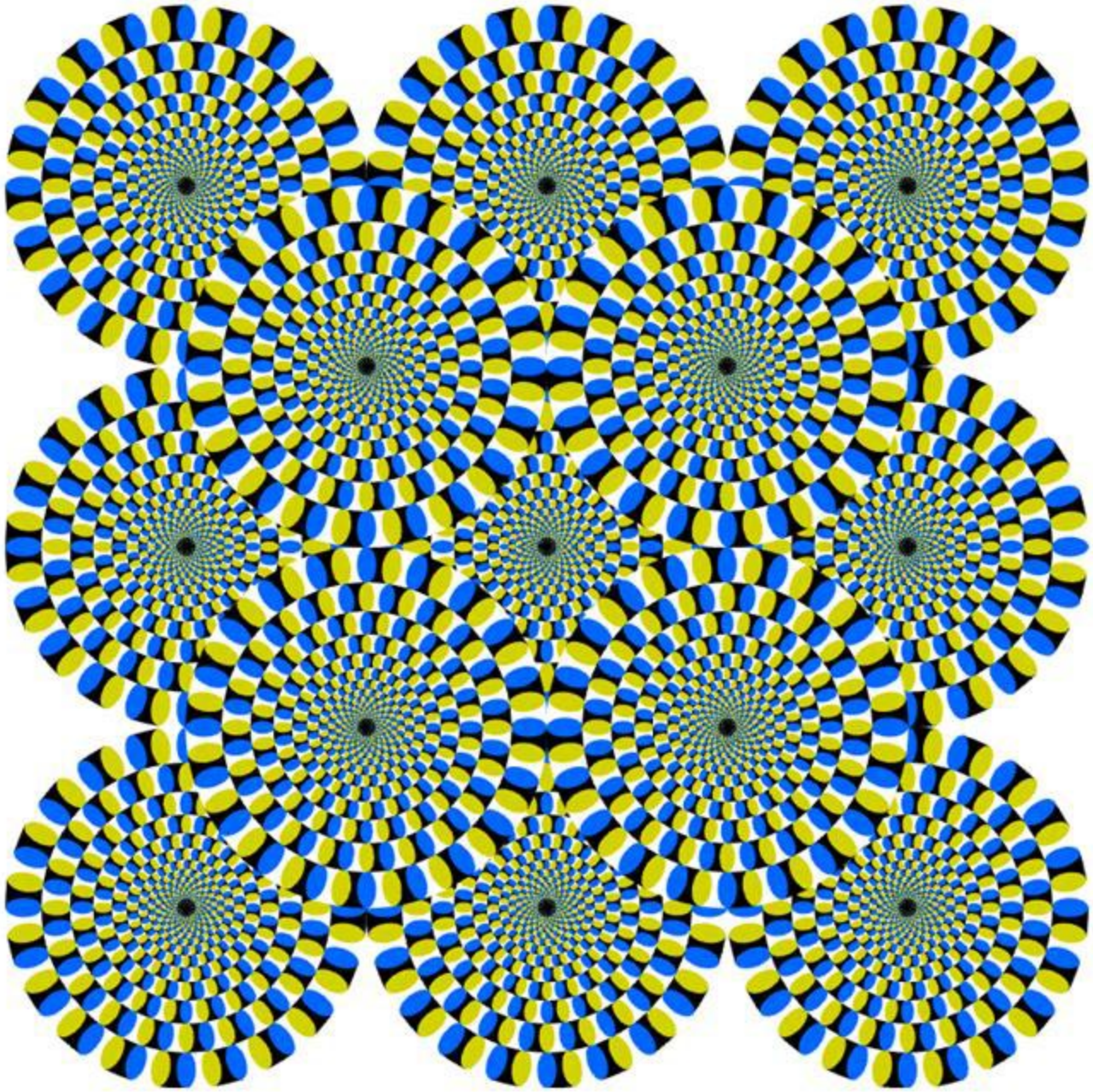
Kitaoka & Ashida (2003)

rotation of the “wheels” occurs in relation to eye movements. On steady fixation the effect vanishes. asymmetric luminance steps are required which triggers motion detectors.

fMRI: significant activation in a motion-sensitive area in the human extrastriate visual cortex during the observation of the figure. Enhanced by eye movements.

Kuriki: J.Vision 2008.

Akiyoshi Kitaoka, Professor, Department of Psychology, Ritsumeikan University, Kyoto, Japan



Simultaneous brightness contrast

When visual signal leaves the eye it has been stripped of amount illumination information.

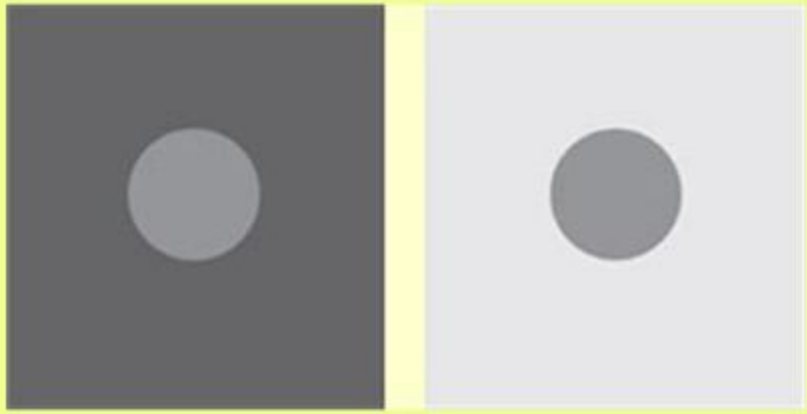
Replaced difference map, where light meets dark.

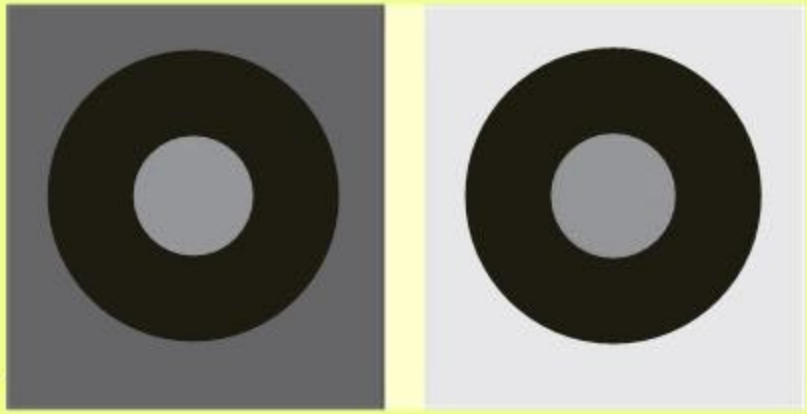
So surfaces reflecting same amount of light can appear differently bright!

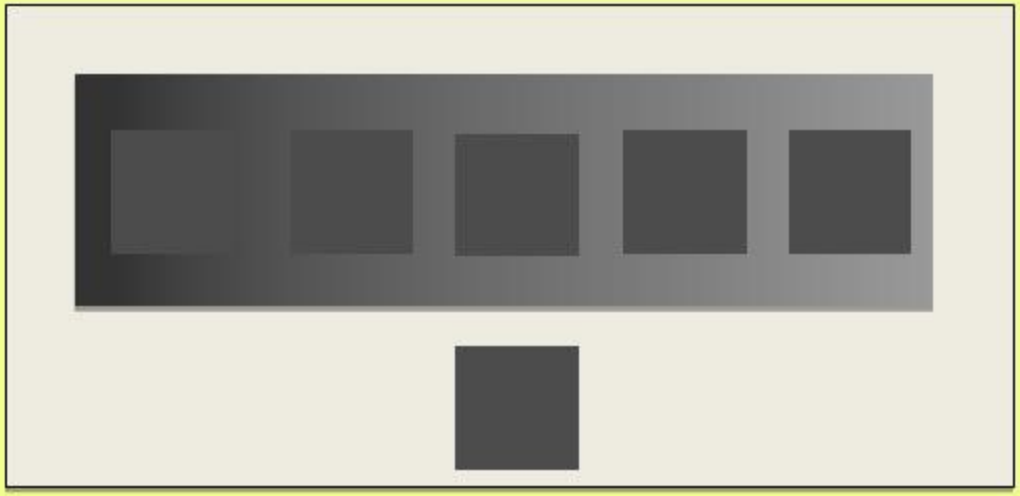
The apparent brightness of a surface, depends both on its own luminance and the luminance of the areas surrounding it.

Context influences perceptions,

the surround affects perception of that object.



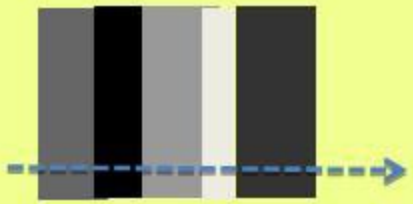


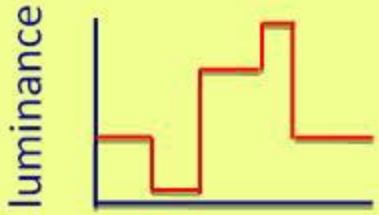


Motion illusions

Repeated asymmetric patterns cause the visual system to infer motion.

Sigmund Exner, postulated specialised micro-circuits in the periphery of our vision for detecting movement.





Gregory & Heard (1983) first to describe that asymmetric luminance steps cause illusory movement.

Fraser and Wilcox's (1979) peripheral drift illusion

Small involuntary eye movements during fixation play an important role.

Backus, B. T., & Oruç, İ. (2005). Illusory motion from change over time in the response to contrast and luminance. *Journal of Vision, 5(11):10*

Morgan: Exner face illusion (Pinna type)

Optical illusion art

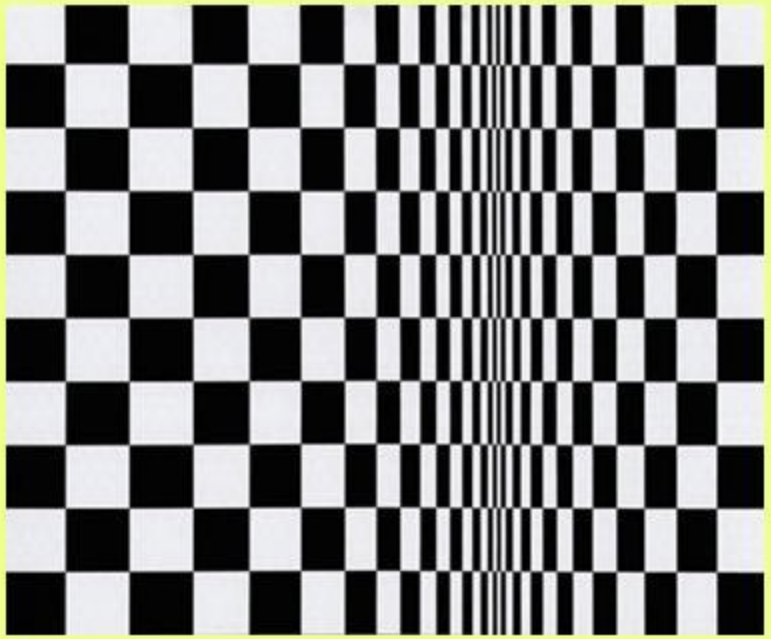
artists such as Bridget Riley, 1931-

Croydon School of Art.

1965: Wm Seitz's *The Responsive Eye*

Exhibited at MOMA NY brought attention to op-art

National Gallery November 2011



Movement in Squares, 1961.

Ouchi

The Ouchi illusion is thought to arise from retinal motion signals, generated either by moving the image, or by small involuntary eye movements while viewing a static pattern (Spillmann et al 1993).

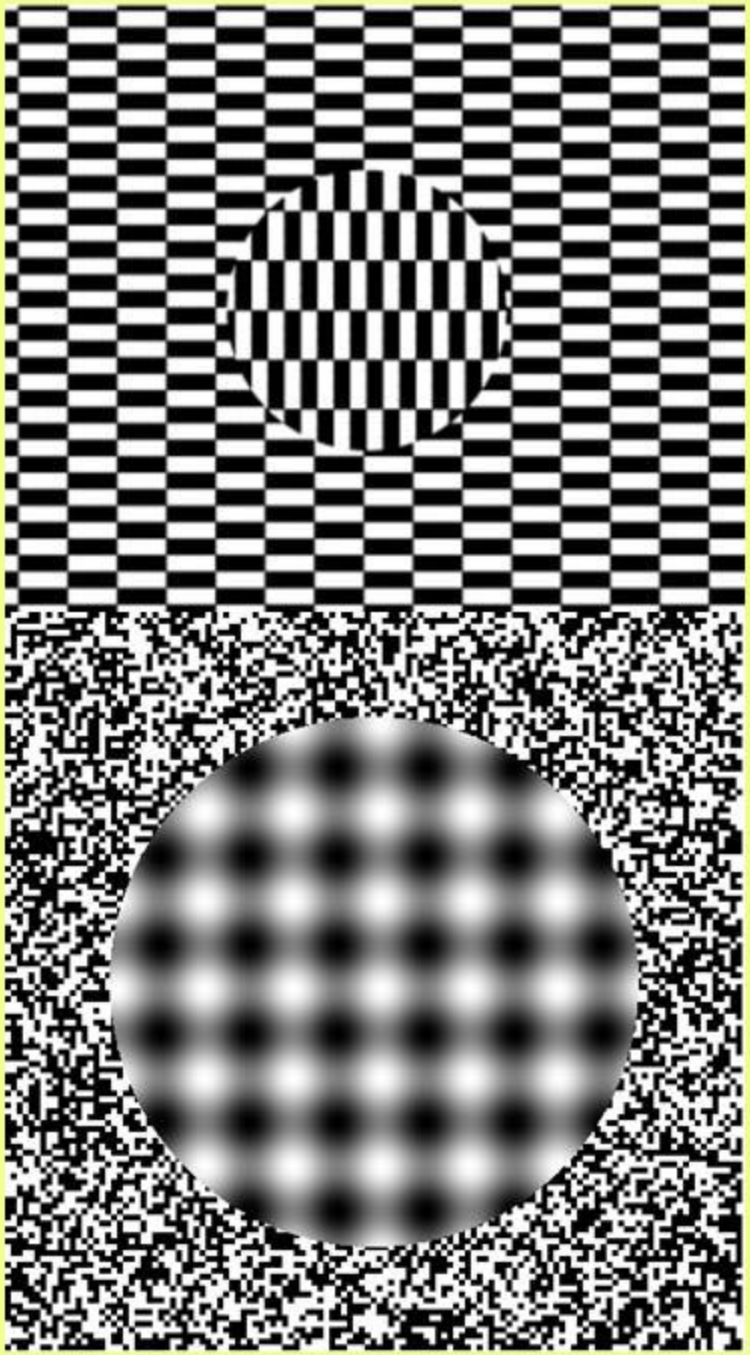


Figure background

Top-down processing: The mind creates meaning to perceptions and memories, using what we already know and believe.

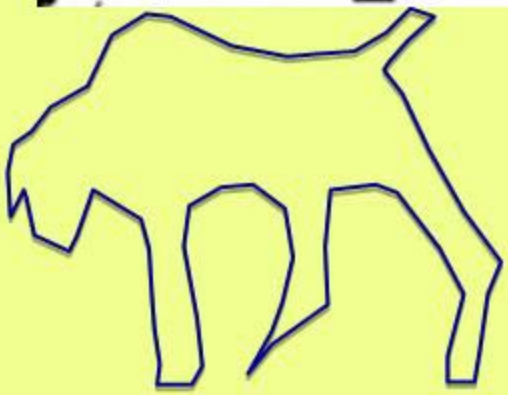
Makes sense of the world even if the information misleading or partial.

Normally enough information to construct a realistic model of the external world.

Leaving out critical information creates illusions.

Ambiguous edges obscure figure and ground, which tend then to be grouped together. Basis of camouflage.

Once seen it can never be unseen again (meaningless to meaningful)



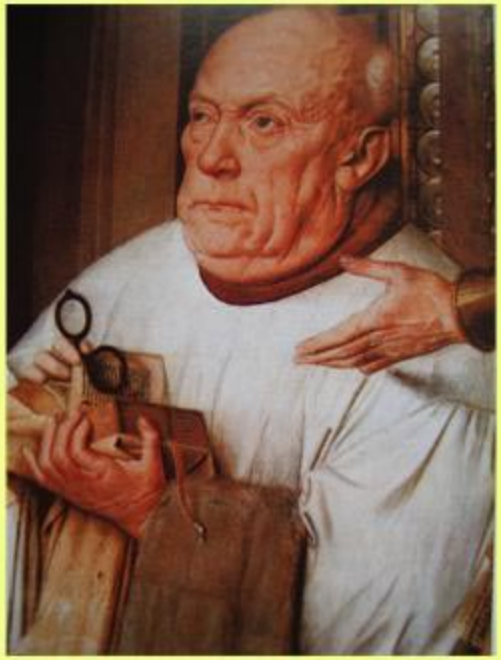
12 13 14

With age crystalline lens less elastic

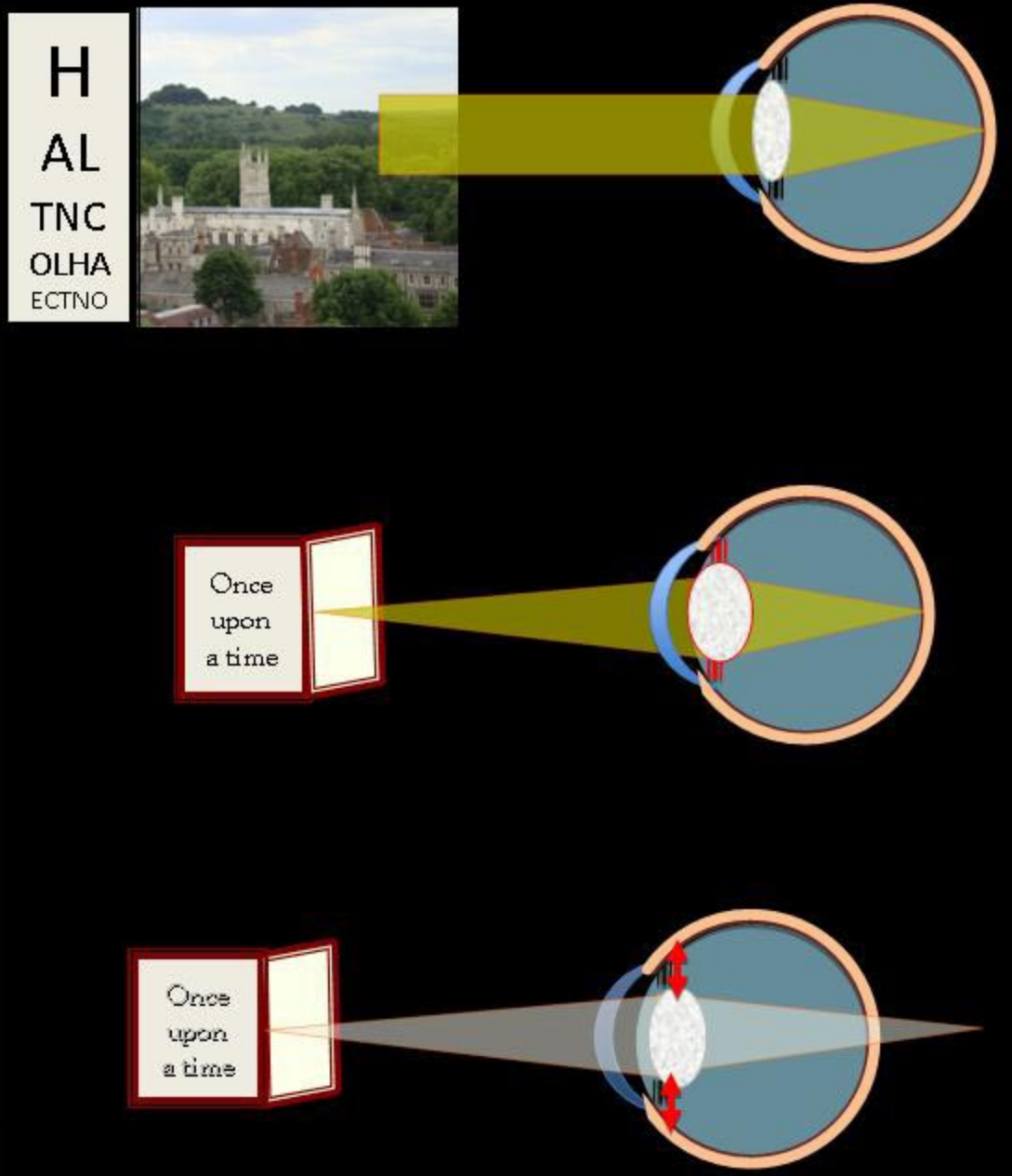
Ciliary muscles unable to accommodate

Many when they wish to read hold the writing at a distance from their eyes so the image may enter they more easily and more sharply:

Dante Alighieri: Convivio BIII Ch9



Jan van Eyck 1436
Madonna met Kanunnik Joris Van der Paele



Jan Van Eyck

La Madone au Chanoine Van der Paele (1434)

Did the ancients use lenses for optical purposes?

George Sines, "Precision in Engraving of Etruscan and Archaic Greek Gems", detailed statistical analysis of nine engraved Etruscan gems. spacings of hatchmarks:

Modern skilled machinist can achieve a precision ~0.2 mm with the unaided eye and with a simple magnifying glass ~t 0.08 mm.

The median spacing on the ancient gems was half this size 0.048mm.

1854: SignifiRoman period magnifying lens in in the "House of the Engraver" on the Stabian Way in Pompeii.

Sines and Sakellearakis, *Lens in Antiquity, American Journal of Archaeology 91 (1987).*

G. Sines, Archeomaterials, Vol. 6, No, 1 (Winter 1992).

Demetrios Plantzos *American Journal of Archaeology, Vol. 101, No. 3 (Jul., 1997), pp. 451-464*

Argues that skill and experience were enough. Perhaps myopia.

Roman Britain, 4thC AD Venus with Cupid (love) and the armour of Mars, common Roman iconography; Thetford hoard of late-Roman gold jewels 1979.
Large carnelian removed from older jewelry & cut down for re-setting.

Medieval lenses

1268: **Roger Bacon:** ***Opus Majus:***

"If anyone examine letters or other minute objects through the medium of crystal or glass or other transparent substance, if it be shaped like the lesser segment of a sphere, with the convex side toward the eye, he will see the letters far better and they will seem larger to him. For this reason such an instrument is useful to all persons and to those with weak eyes for they can see any letter, however small, if magnifier enough".

Sophisticated lens-making techniques 1,000 years ago.

Lens-shaped objects made of rock crystal (quartz) found in several Viking hoards on the island of Gotland, Sweden, 11/12th C.

imaging quality comparable to the modern aspheric lenses used, e.g., in today's projectors

The craftsmen used trial and error, since the maths to calculate the best form for a lens not yet discovered.
possibly only a few craftsmen, perhaps a single person, in Byzantium or Eastern Europe

Schmidt et al,
(Optometry and vision scienc 1999).

Gospel according to Matthew,

Xristi

autemgene

Rationsicerat

"The birth of Christ took place thus."

Eadfrith. Lindesfarne.

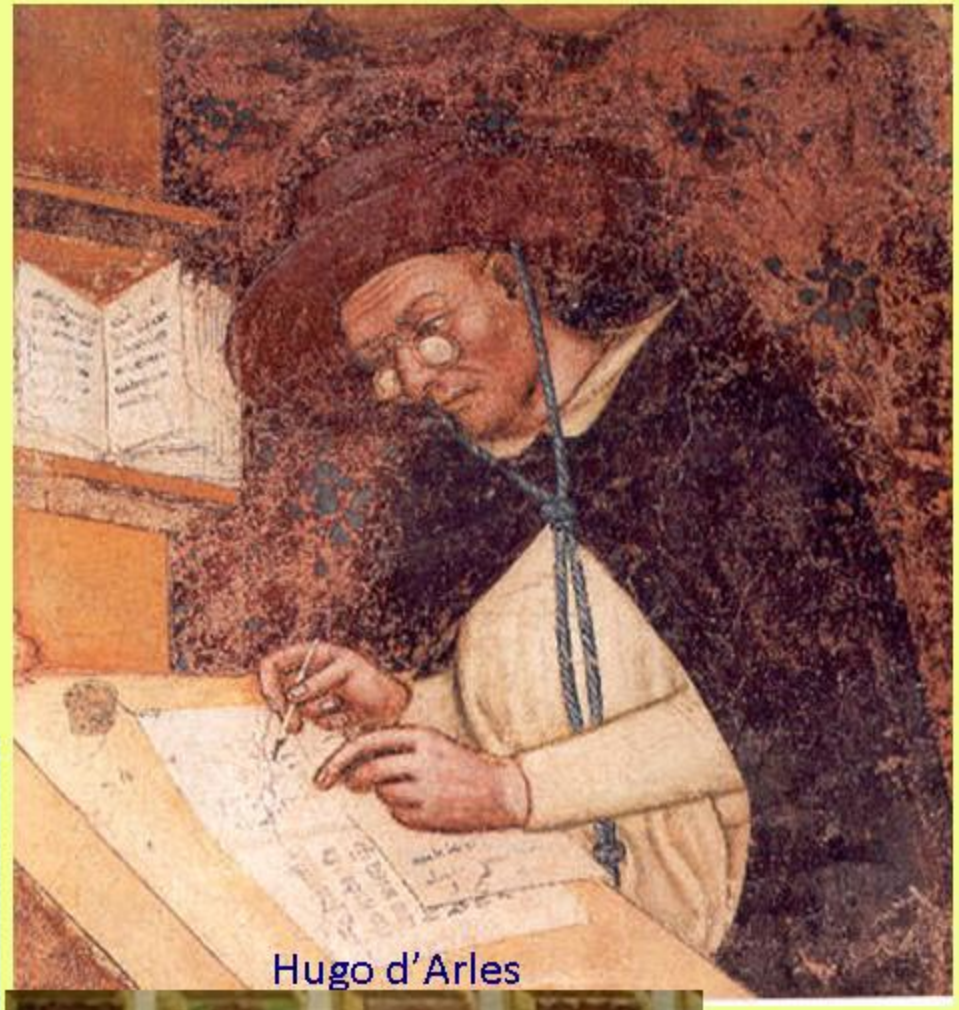
First depiction of spectacles

1352 Tomaso da Modena, son of painter, Barisino Barisini.

Hired by Prior of S. Nicolo, Treviso. He wanted the general chapter of the Dominicans to move to Treviso

Friar Ugone de Provenza (Cardinal Hugh of Provence first Cardinal of the order). These rivet spectacles are the first pictorial representation of spectacles.

Hugh never wore specs; he died 20 years before they were invented but Tomaso thought a man of his age would have needed them.



Hugo d'Arles