CNR-INO

ISTITUTO NAZIONALE DI OTTICA

CONSIGLIO NAZIONALE DELLE RICERCHE

Viareggio, 3 July 2019

The Lighting Experience

Speaker:

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Evento:

LIGHTING DESIGN CAMPUS 2019

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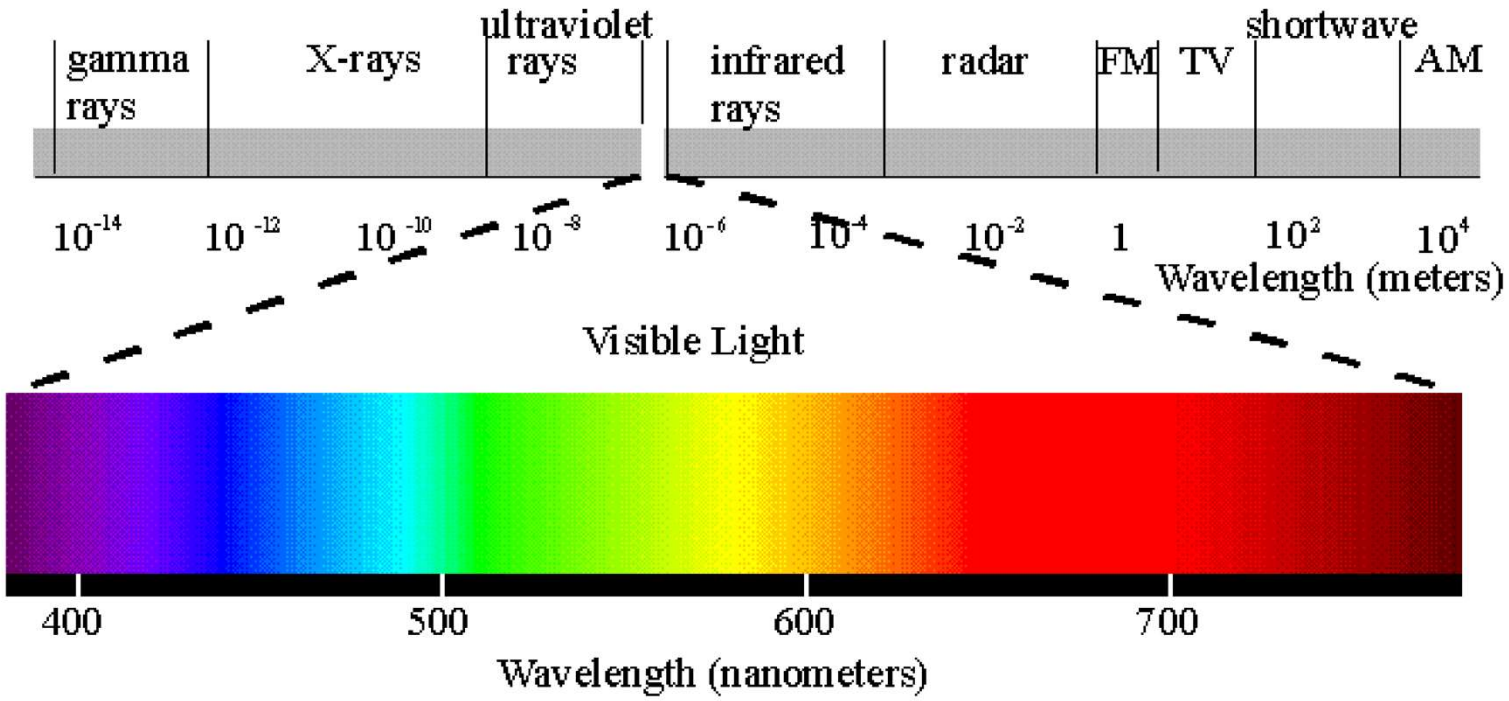
Lighting and behavior

- Relationship between lighting and behavior. But….
- The Hawthorne effect is a type of reactivity in which individuals modify an aspect of their behavior in response to their awareness of being observed(Mayo, 1933) (Nelson e Quick 2003)

Visible part of the spectrum



From 380 to 780 nm (1 nm is one billionth of a meter, one millionth of a millimeter)

Question

Where do brown and magenta fit in the electromagnetic spectrum?

It doesn't! In the spectrum we can't find mixture

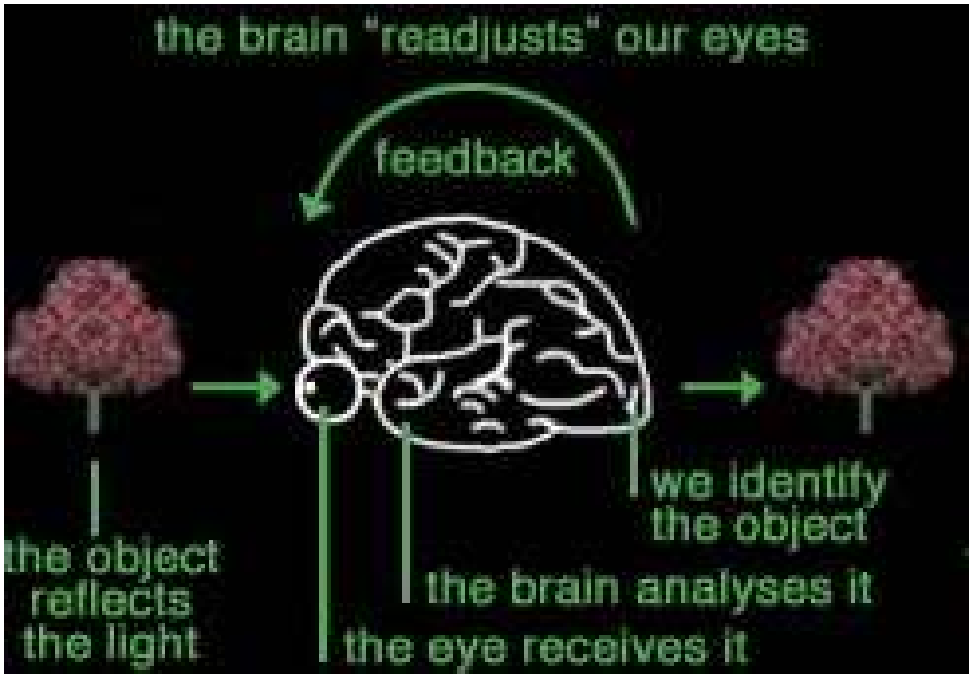
Color naming experiment

http://www.hpl.hp.com/personal/Nathan_Moroney/mlcn.html

http://www.hpl.hp.com/personal/Nathan_Moroney

What is vision?

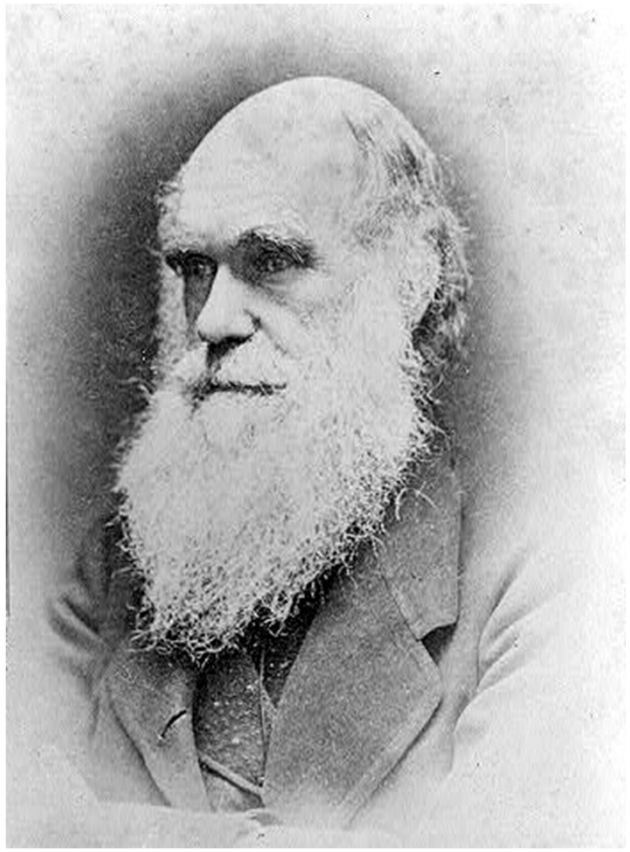
"...to know what is where by looking. In other word, vision is the process of discovering from images what is present in the world, and where it is The study of vision must therefore include not only the study of how to extract from images the various aspects of the world that are useful to us, but also an inquiry into the nature of the internal representations by which we capture this information and thus make it available as a basis for decisions about our thoughts and actions." *D.Marr "Vision" (MIT Press, Boston, 1980)*



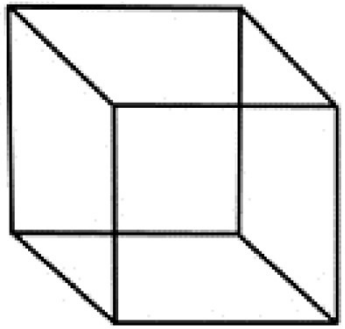
Darwin

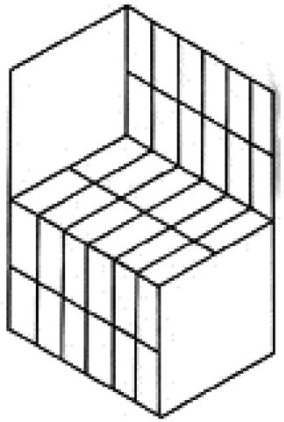
"To suppose that the eye with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I confess, absurd in the highest degree".

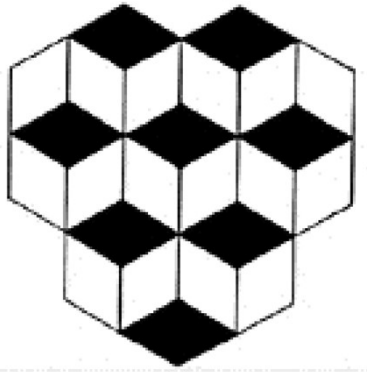
Charles Darwin, The Origin of Species, John Murray, London, 1859



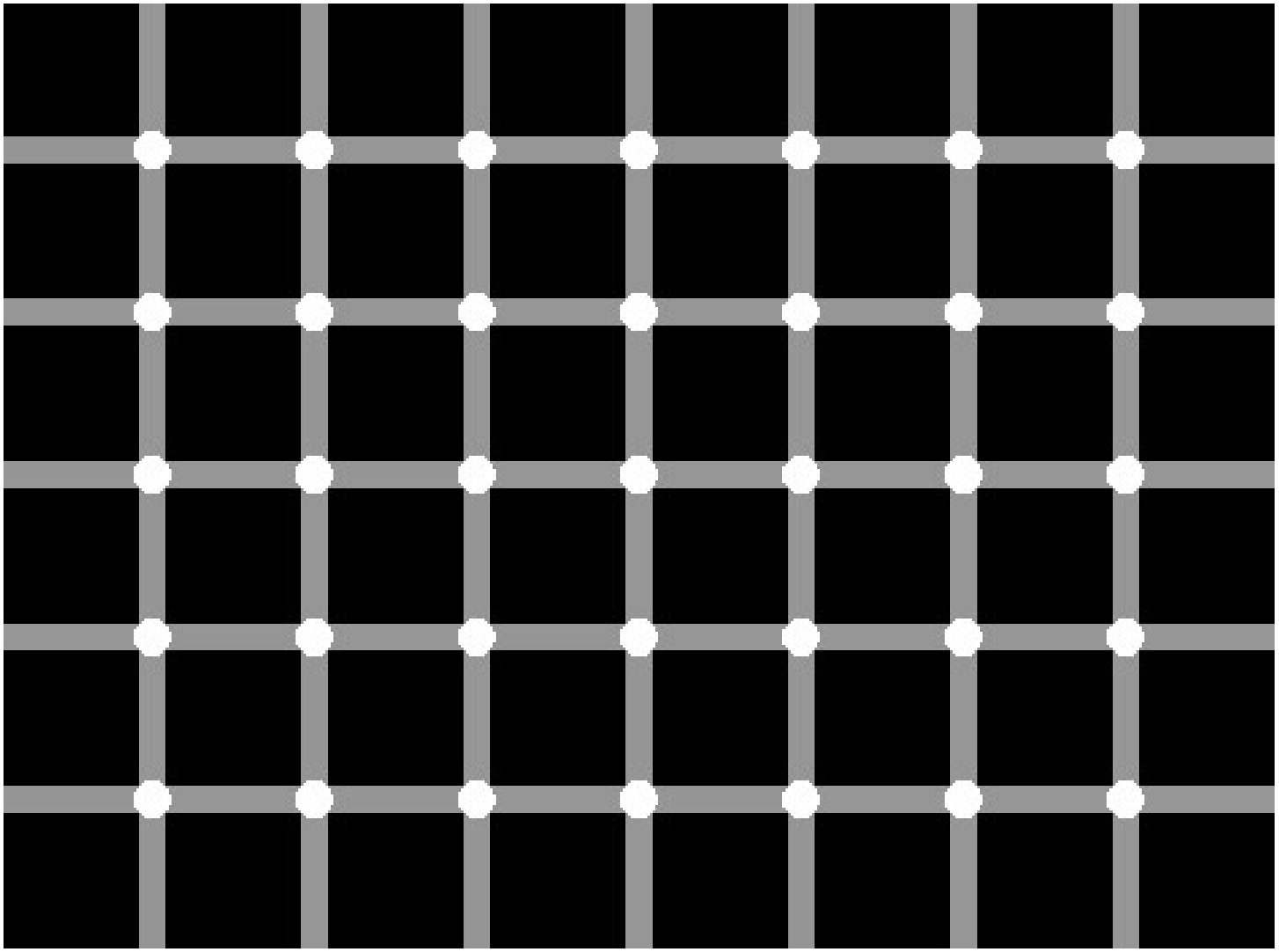
Same image, different perception



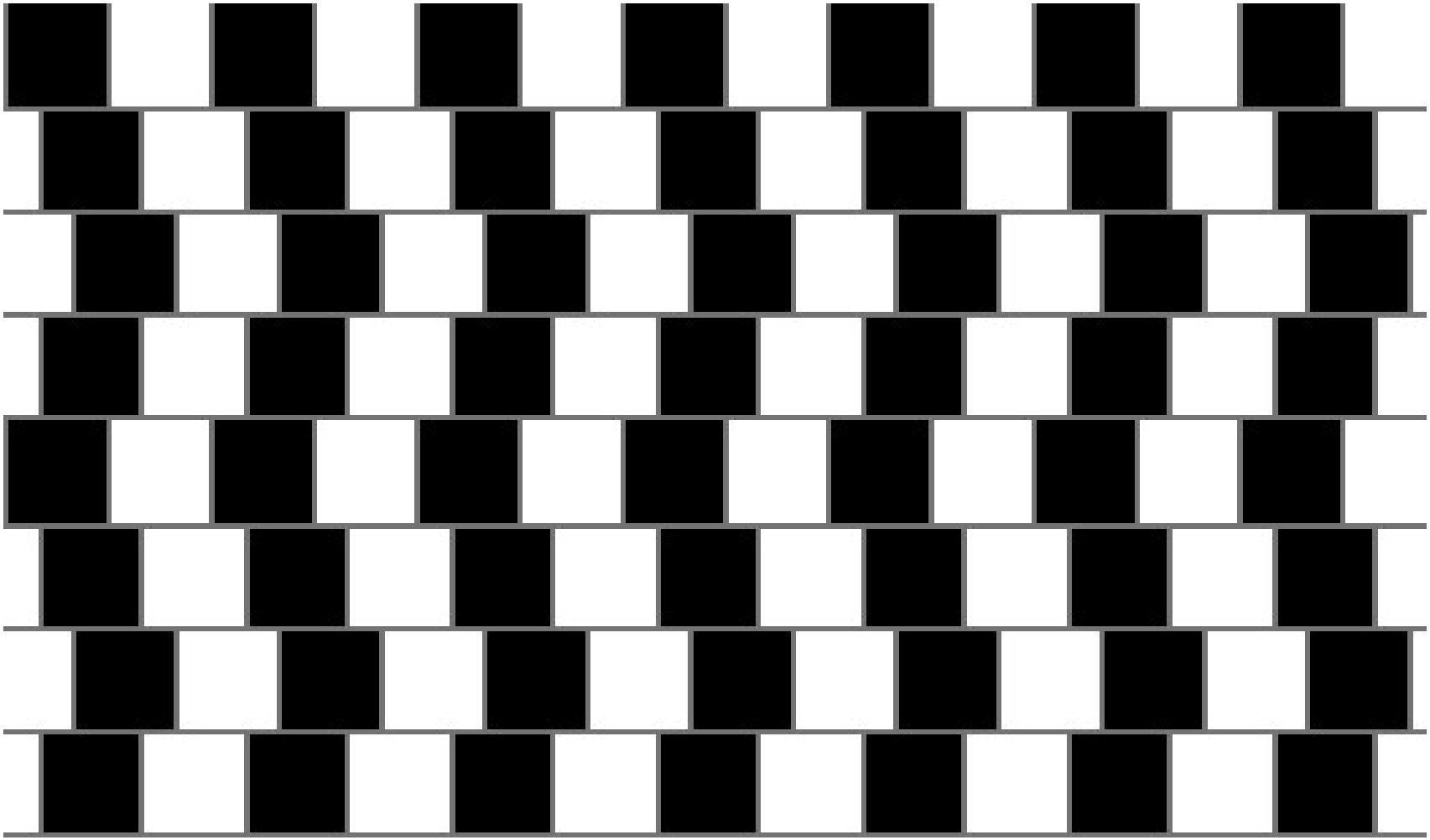




Count the black dots!



Are the horizontal lines parallel or do they slope?



To create your own

To create your own

http://illusionsetc.blogspot.com/2006/05/how-to-create-your-own-colorization.html

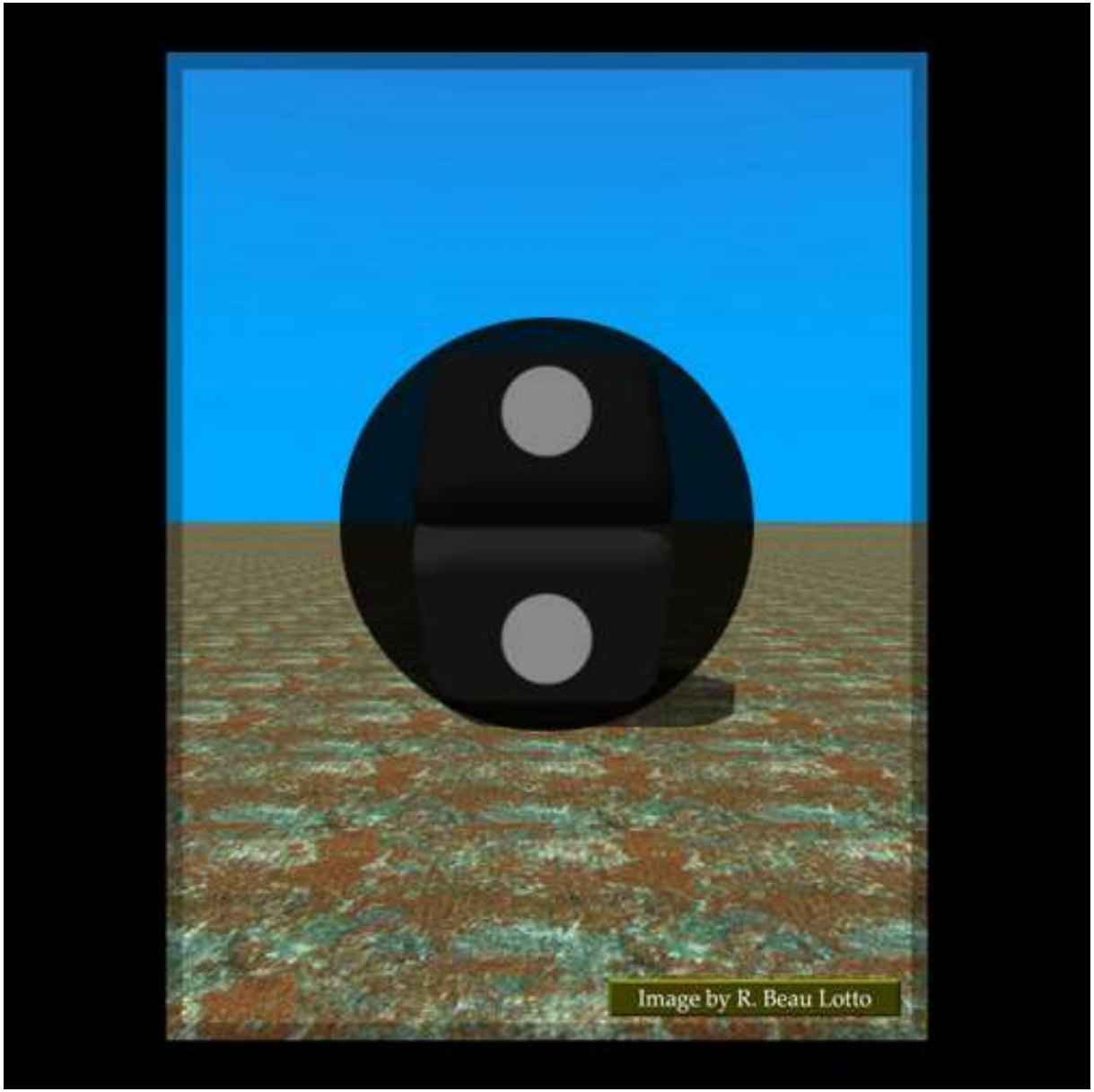
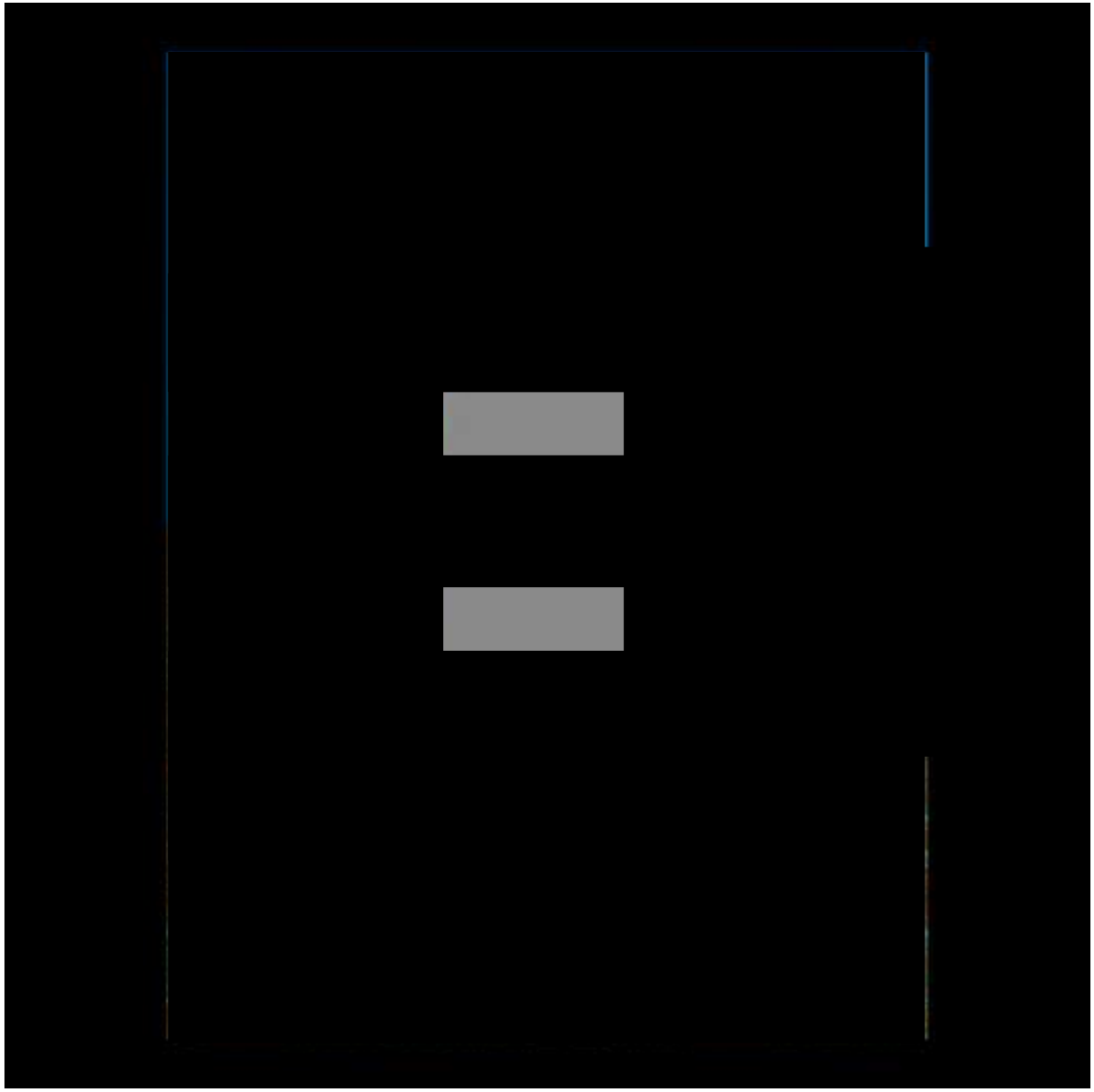
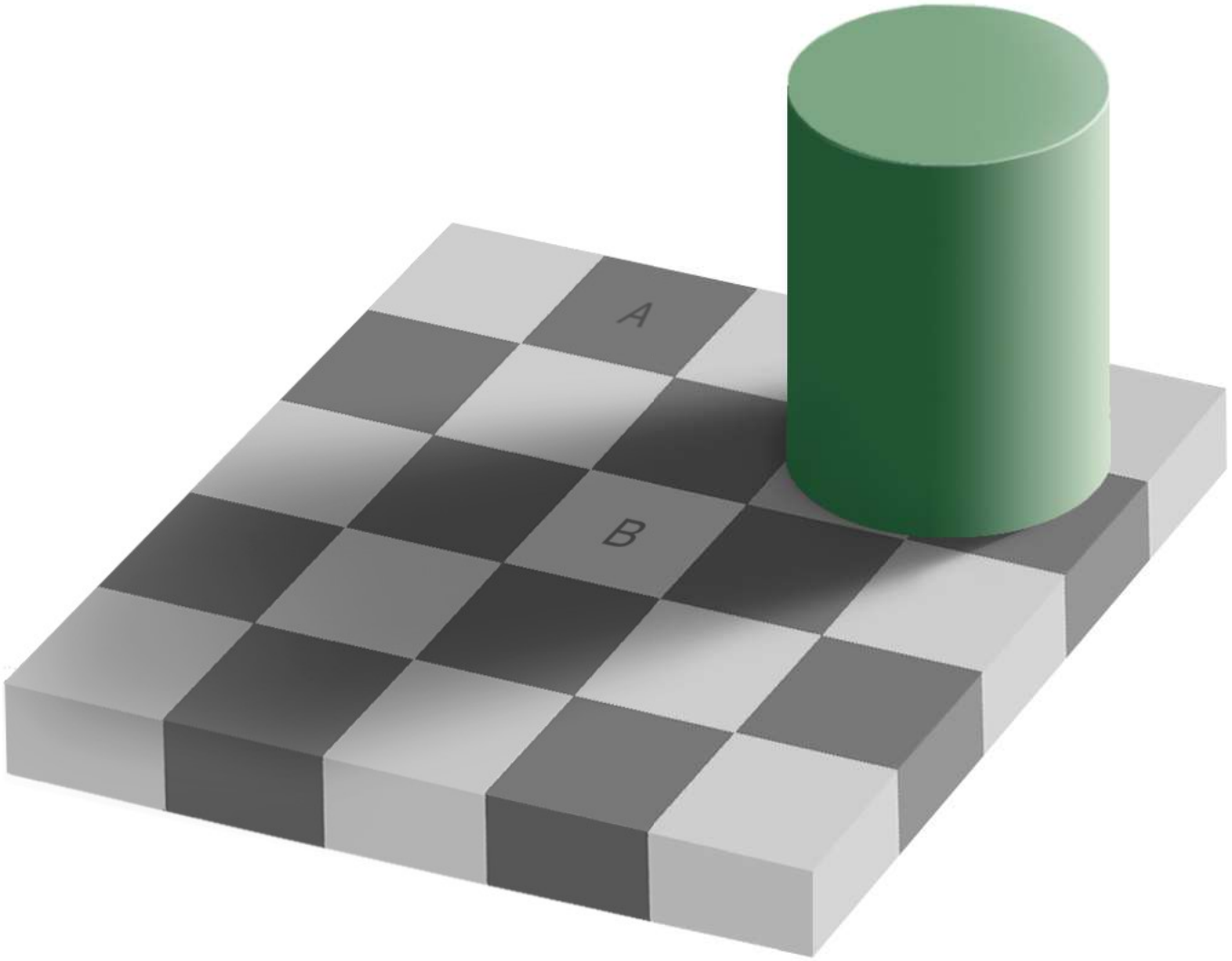


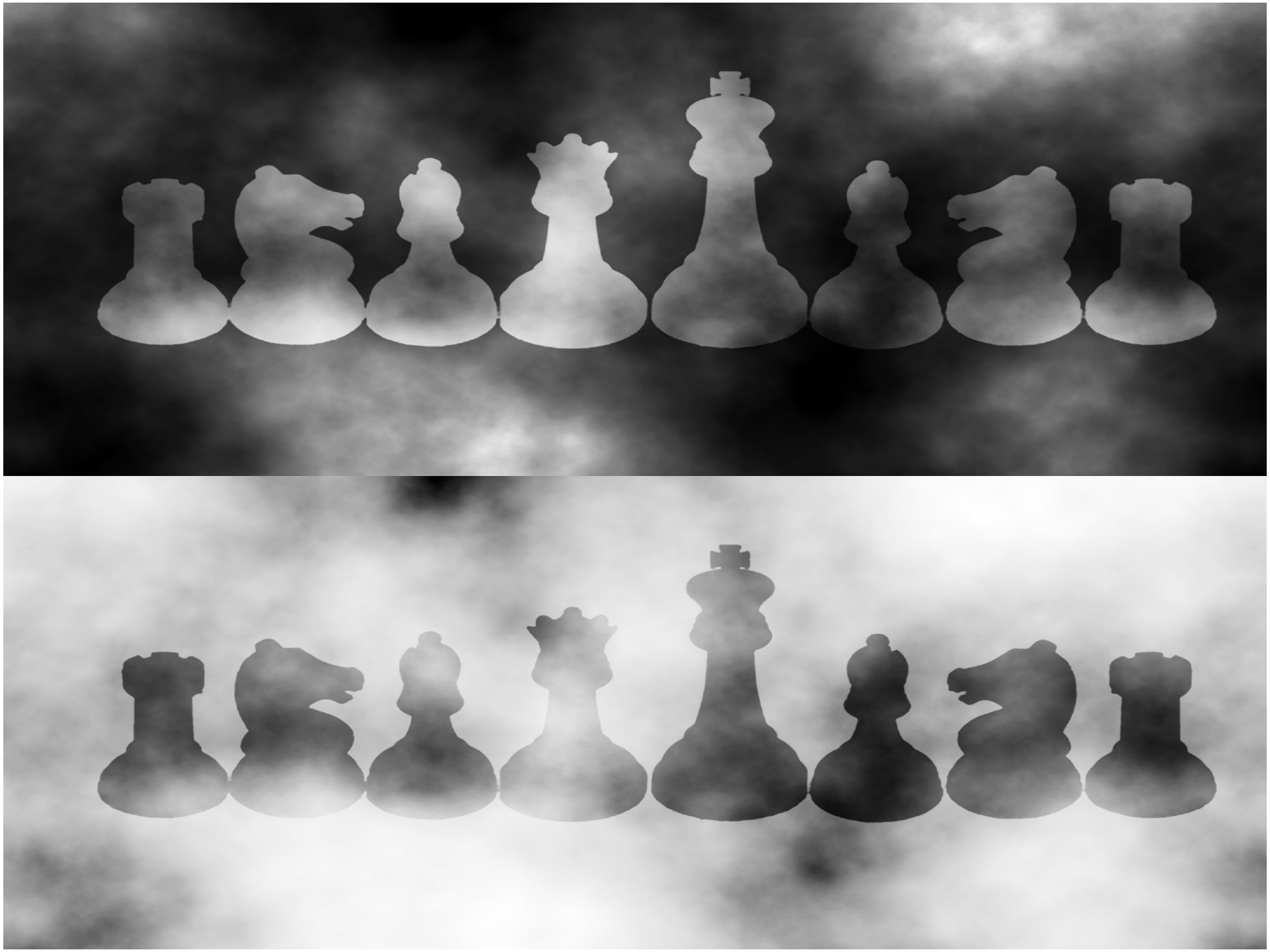
Image by R. Beau Lotto

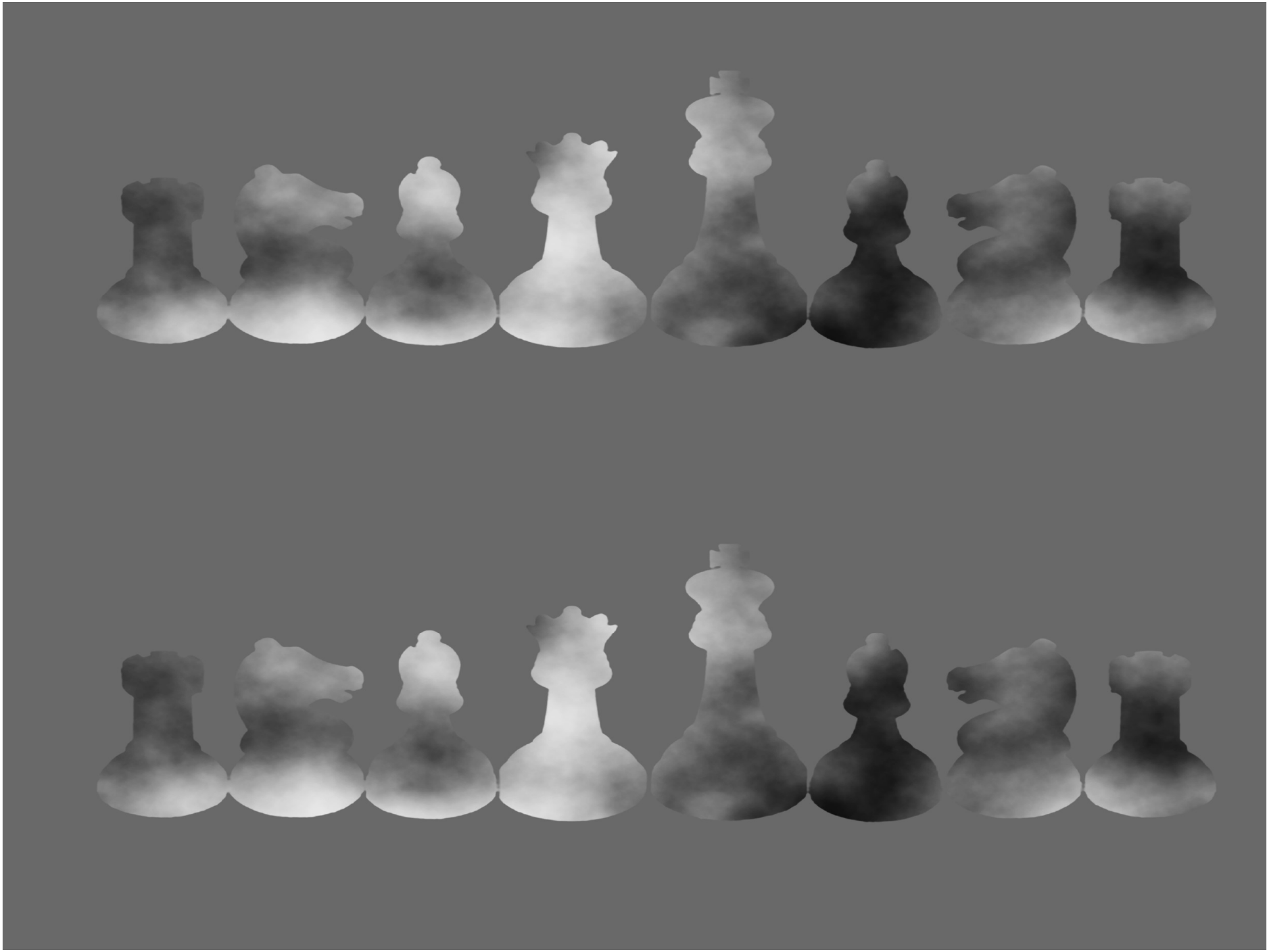


The Checkershadow Illusion

web.mit.edu/persci/people/adelson/checkershadow_illusion.html







Anderson e Winawer (2005)

What is color?
Are we equally sensitive to all wavelengths?
Is color an objective or subjective phenomenon?

Photometry

Photometry measures light from the point of view of our visual system. It must take into account that our eyes are not equally sensitive to all wavelengths. We see yellow-green far better than red and blue.

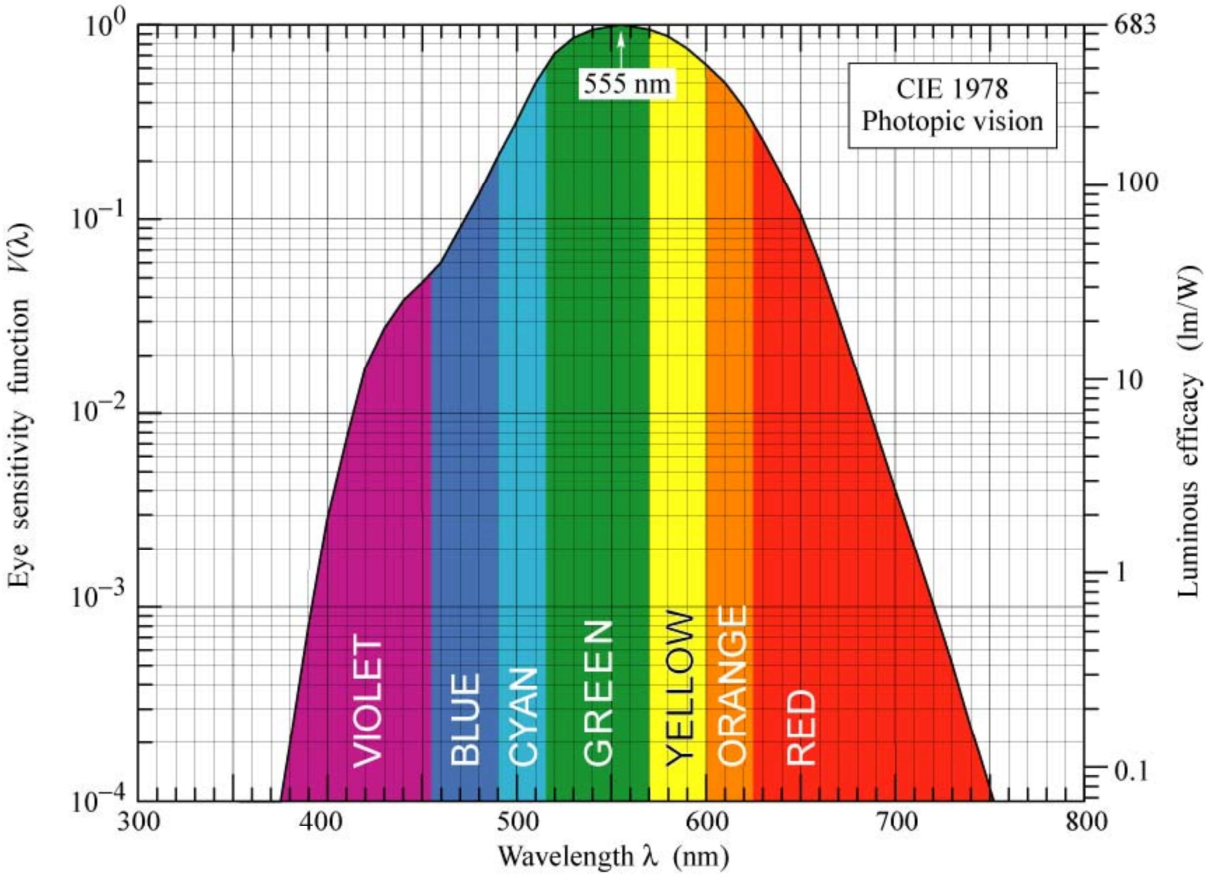


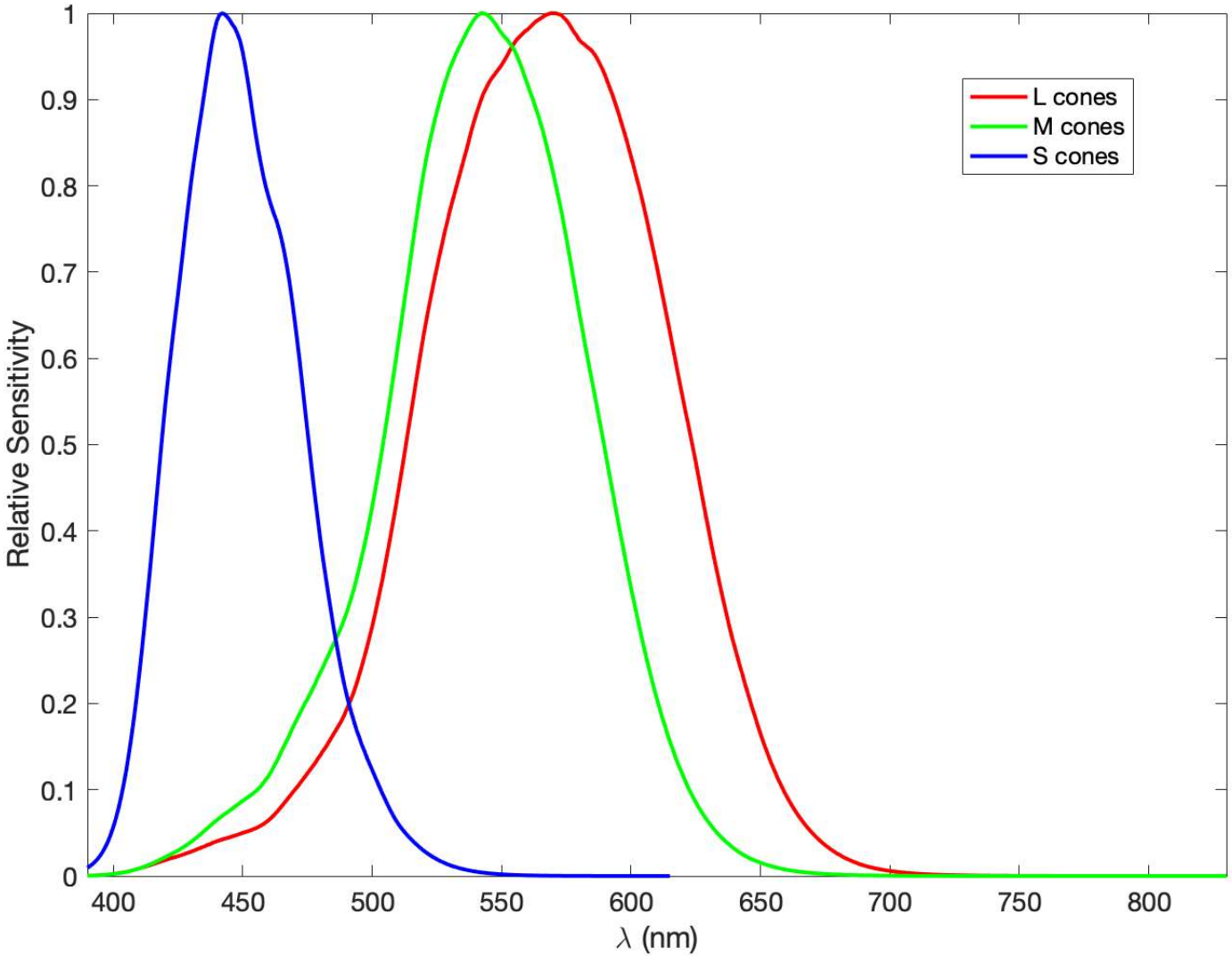
Fig. 16.7. Eye sensitivity function, $V(\lambda)$, (left ordinate) and luminous efficacy, measured in lumens per Watt of optical power (right ordinate). $V(\lambda)$ is greatest at 555 nm. Also given is a polynomial approximation for $V(\lambda)$ (after 1978 CIE data).

Color and appearance

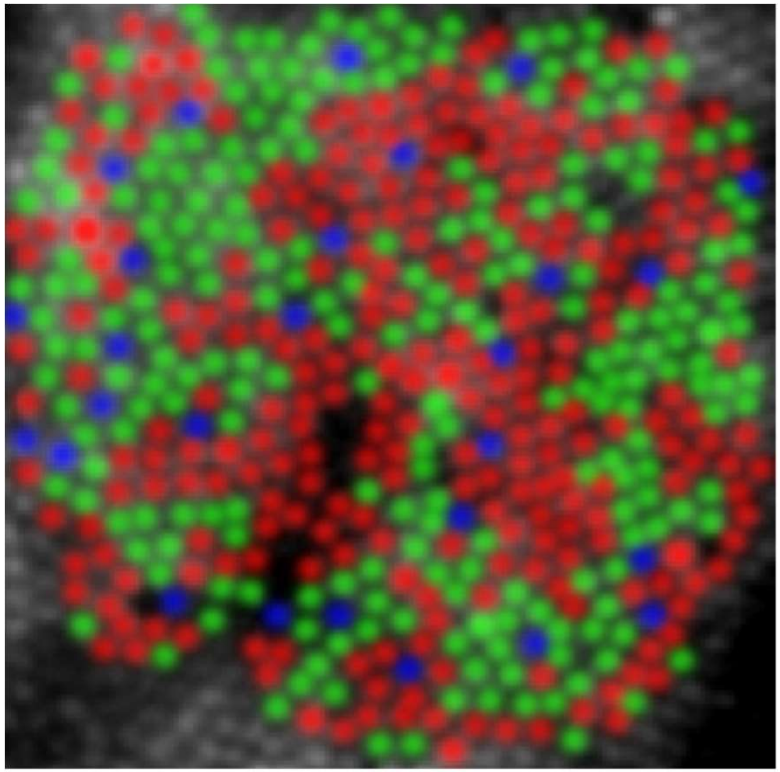
The rendering of an object color depends on

- visual mechanism of the viewer
- object's composition
- the spectral qualities of light sources
- size (colors covering a large area tend to appear brighter and more vivid)
- background differences
- ……

Relative sensitivity of the eye: three cones

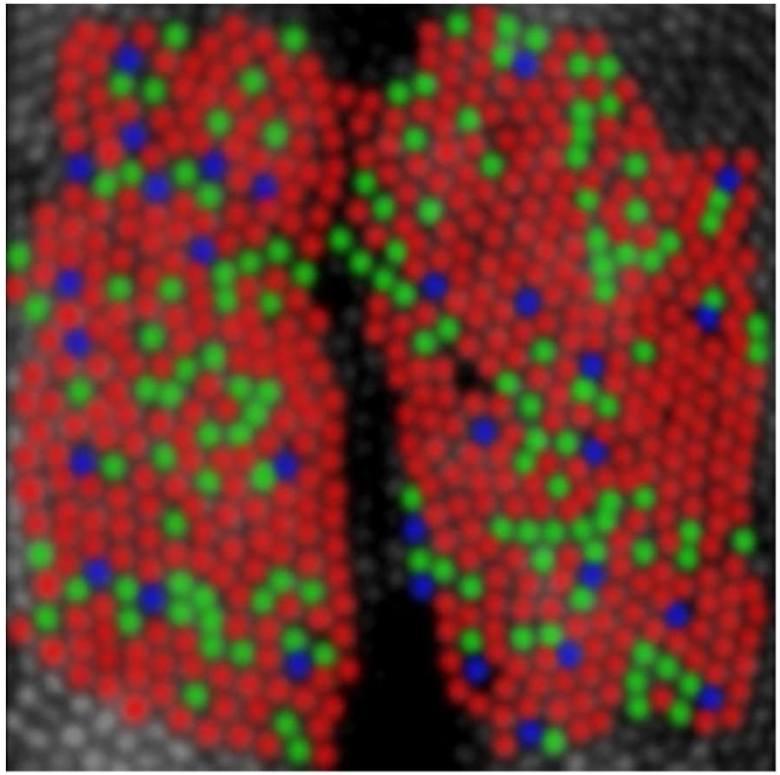


Cones Distribution



L 50.6% M 44.2% S 5.2%

L:M=1.15

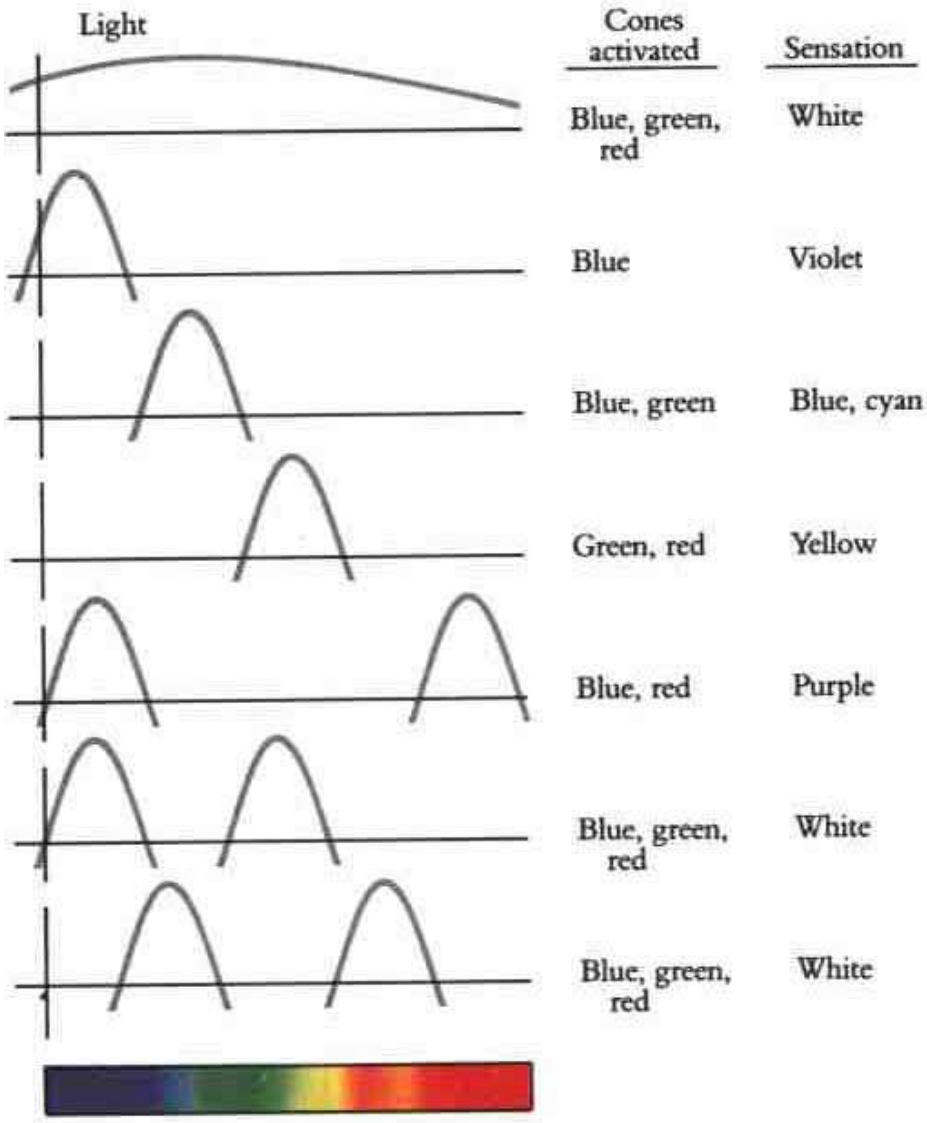


L 75.8% M 20.0% S 4.2%

L:M=3.79

Roorda e Williams *Nature* **397**, 520 (1999)

What is white?



What is white? (a mathematical point of view)

White is the sum of all the colors.

False!

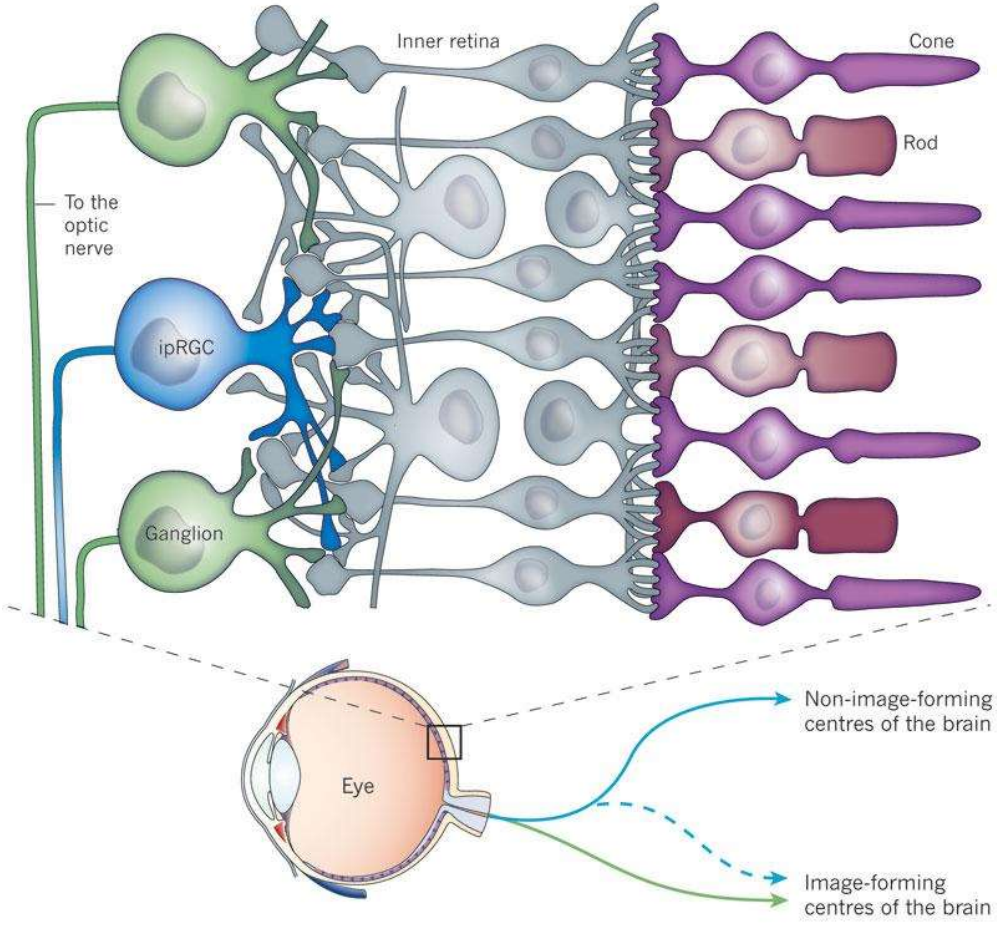
The sum of all the colors of light add up to white.

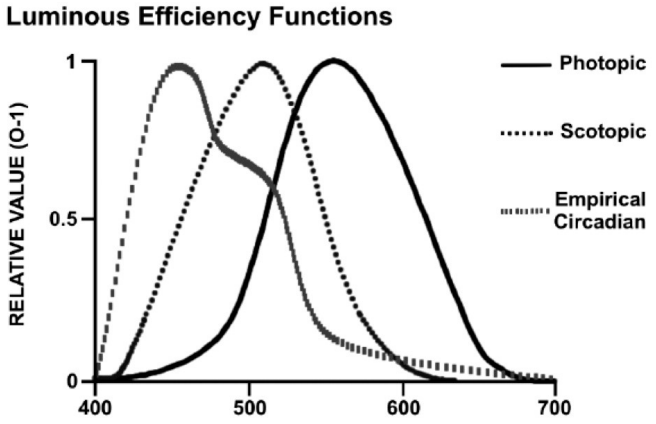
True!

Our retina and the third photoreceptor

LIGHT IN LAYERS

Light passes through the ganglion layer and cells in the inner retina to the predominant photoreceptors in the eye — the rods and cones. These then send visual information back to ganglion cells, which transmit it to visual and non-visual centres of the brain. A subset of ganglion cells, called intrinsically photoreceptive retinal ganglion cells (ipRGCs), contain a photopigment, melanopsin, and can also encode and transmit information about light directly.



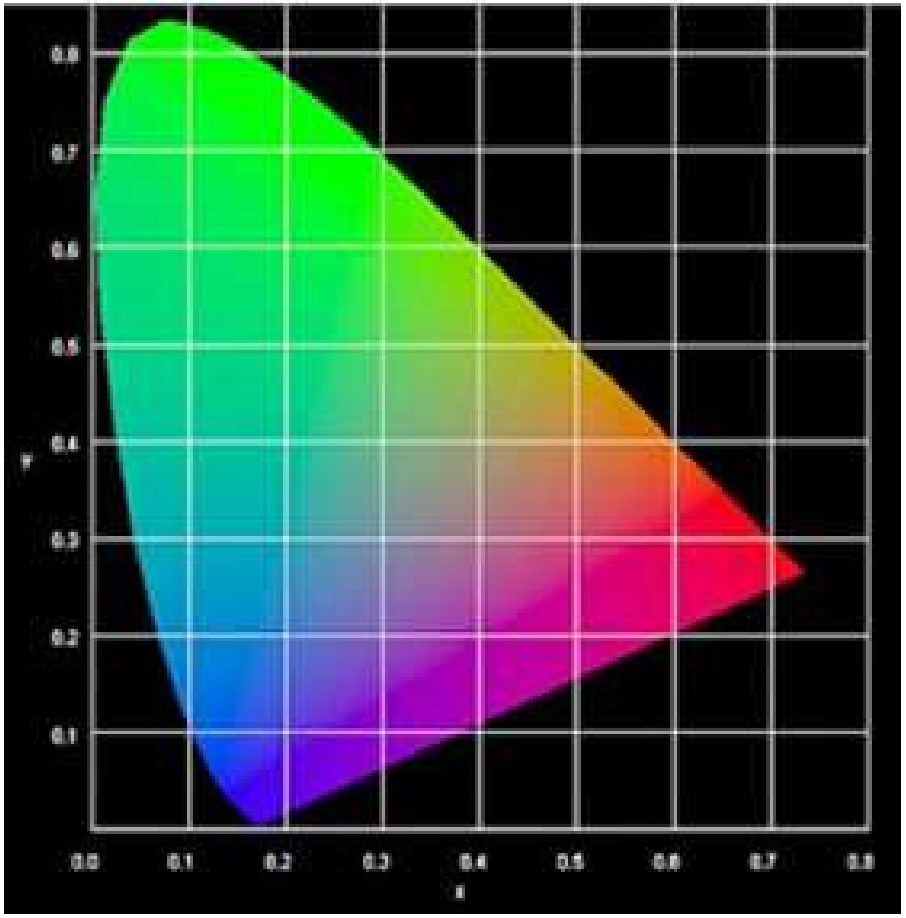


Three colors!

Physics' world (very theoretical): any color at all can be made from three different colors (but using also the minus sign)

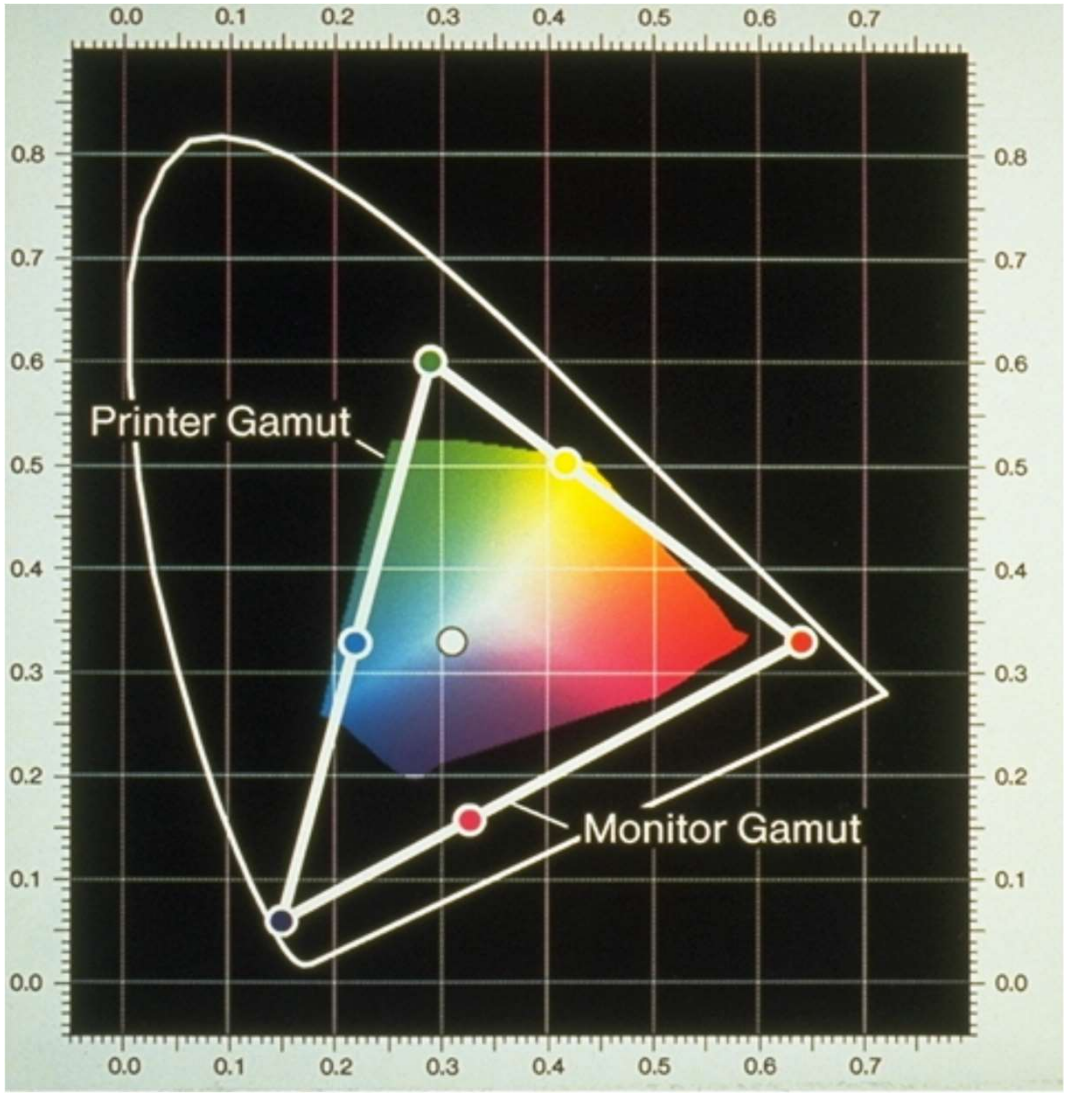
Real world: it is impossible to obtain every color using three colors

CIE chromaticity diagram



In the CIE 1931 diagram (old, but still used in many applications) a color is represented by three numbers, x, y (coordinates in the diagram) and Y (luminance, the amount of light that is reflected or is emitted from a particular area)

Unsolvable problem



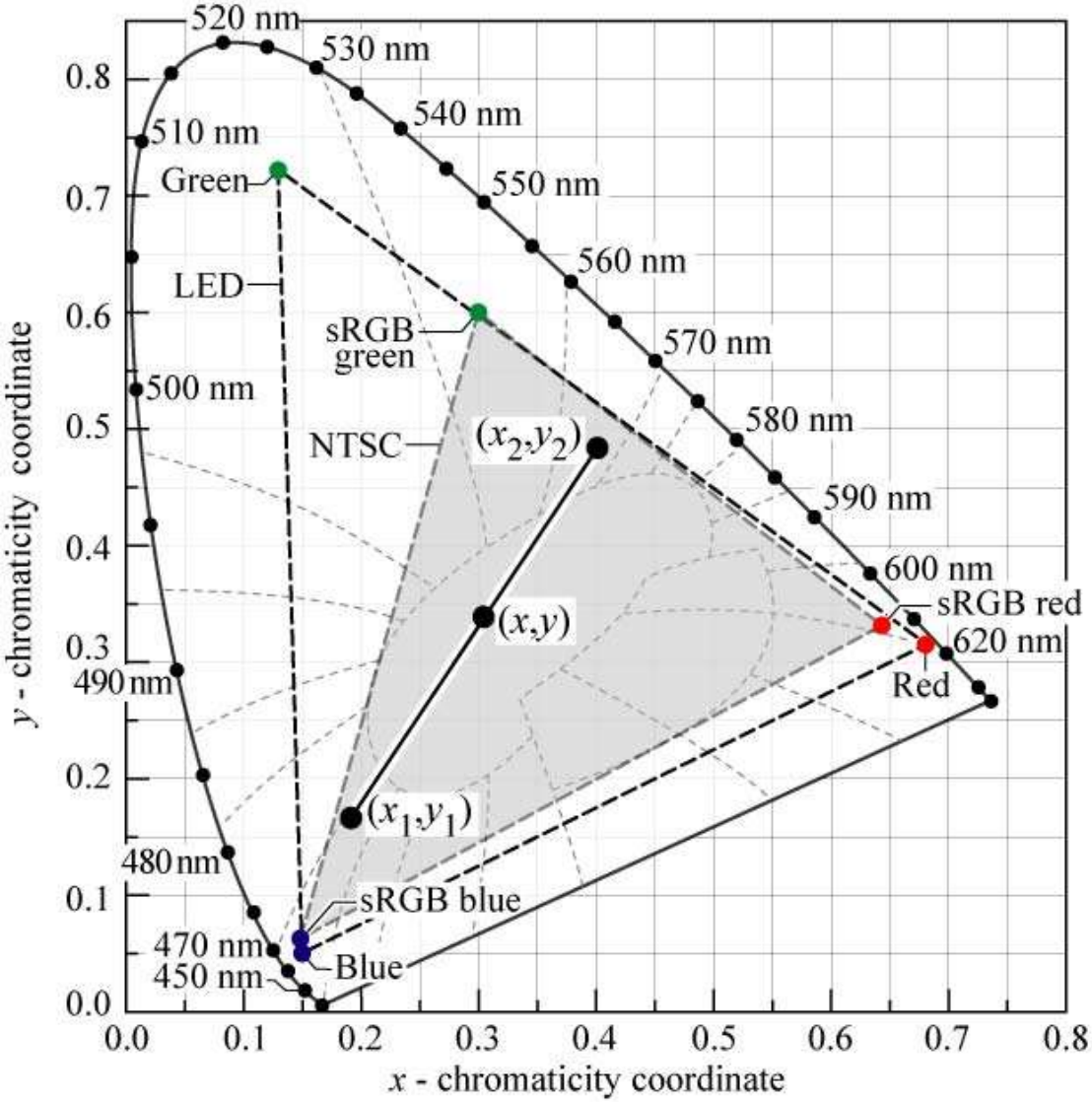
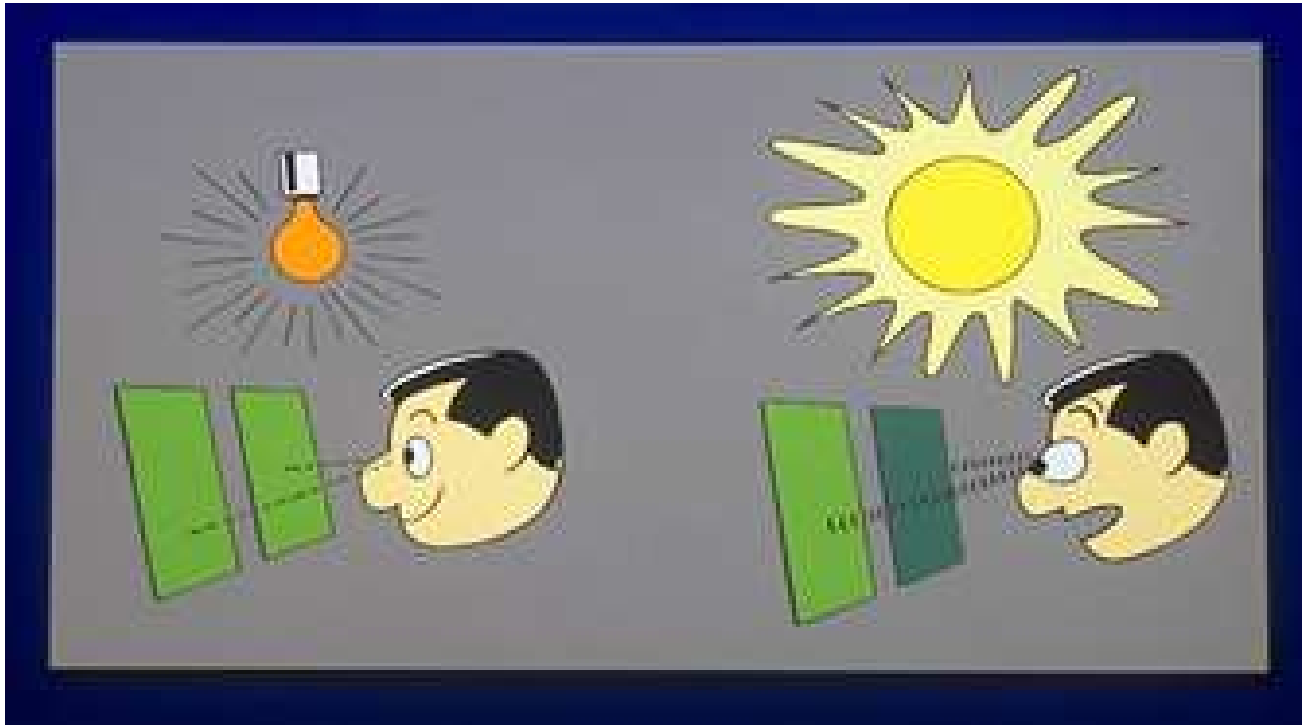
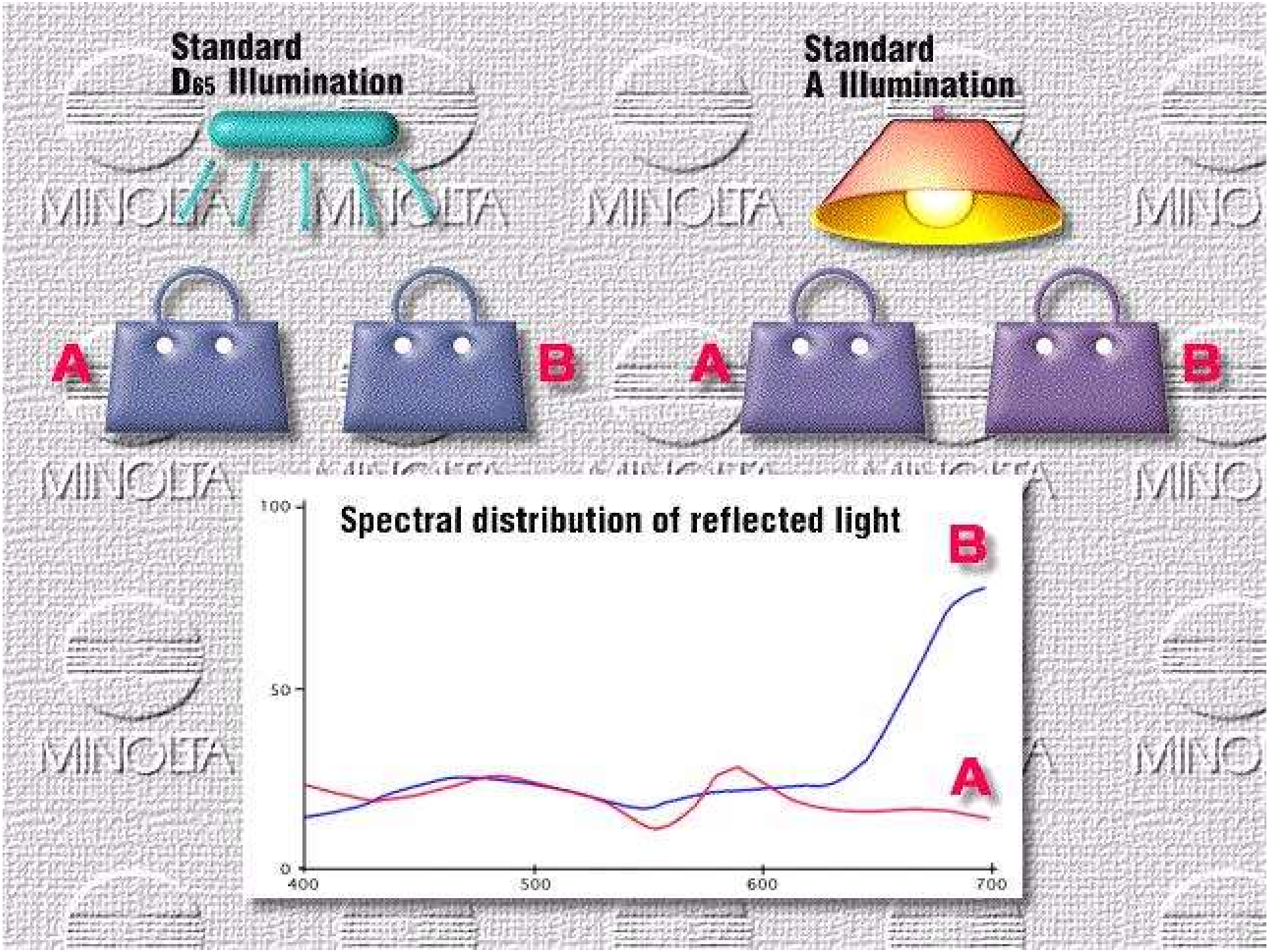


Fig. 19.2. Principle of color mixing illustrated with two light sources with chromaticity coordinates (x_1, y_1) and (x_2, y_2). The resulting color has the coordinates (x, y). Also shown is the triangular area of the chromaticity diagram (color gamut) accessible by additive mixing of a red, green, and blue LED. The locations of the red, green, and blue phosphors of the sRGB display standard ($x_r = 0.64$, $y_r = 0.33$, $x_g = 0.30$, $y_g = 0.60$, $x_b = 0.15$, $y_b = 0.06$) are also shown. The sRGB standard is similar to the NTSC standard.

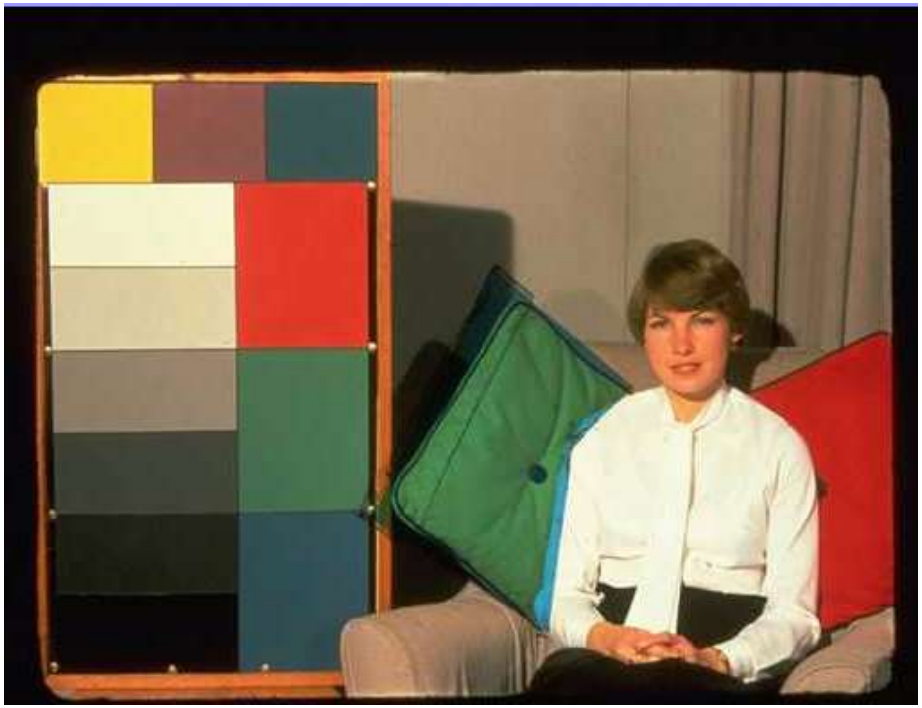
Metamerism

Colors may appear to match under one light source, but not under another: is the metamerism. Two colors that have the same appearance but different spectral reflectance distributions are defined a a metameric pair



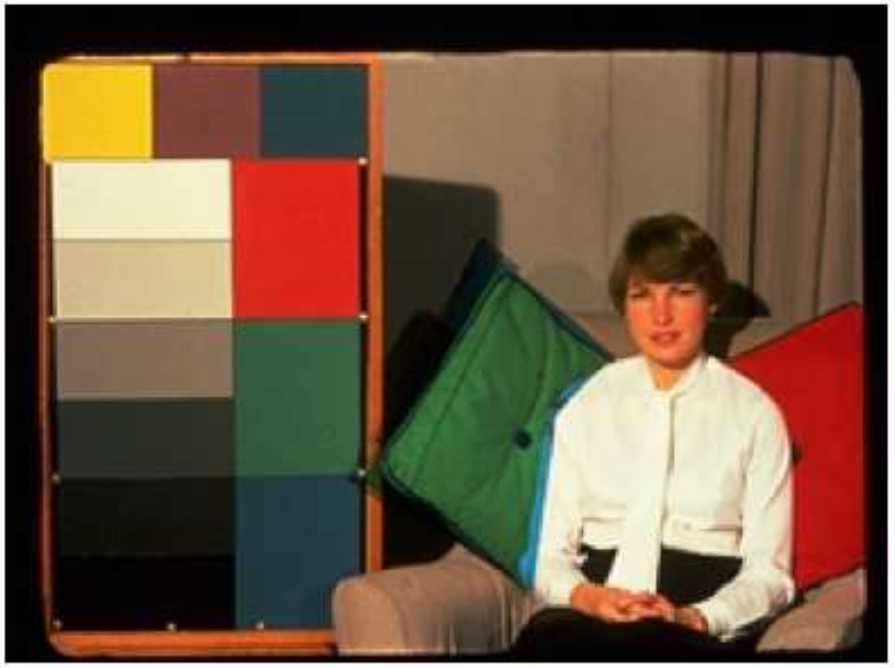

Standard
D65 Illumination
Standard
A Illumination
A
B
A
B
Spectral distribution of reflected light
100
50
0
400
500
600
700
B
A

Color constancy

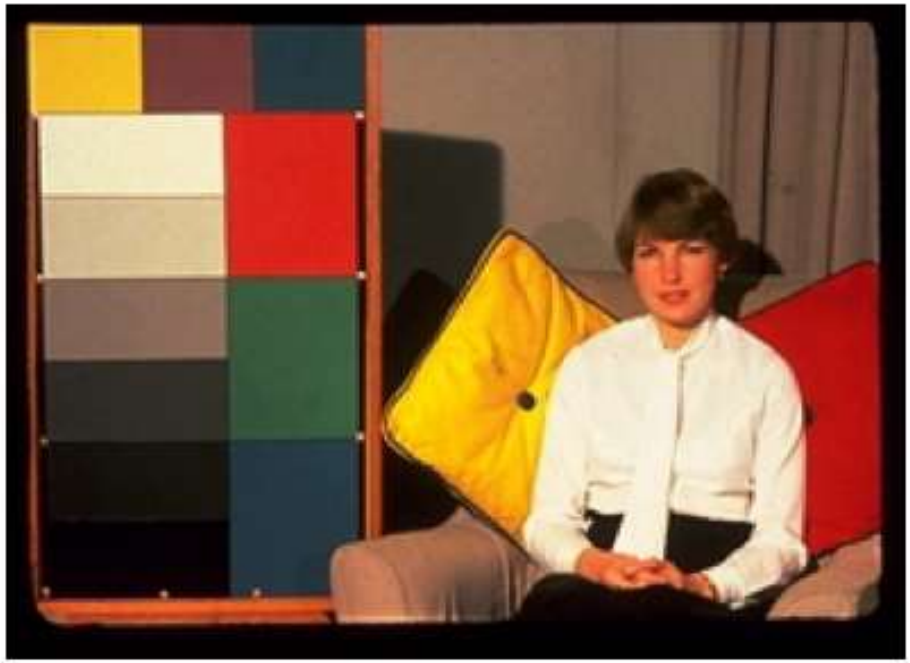


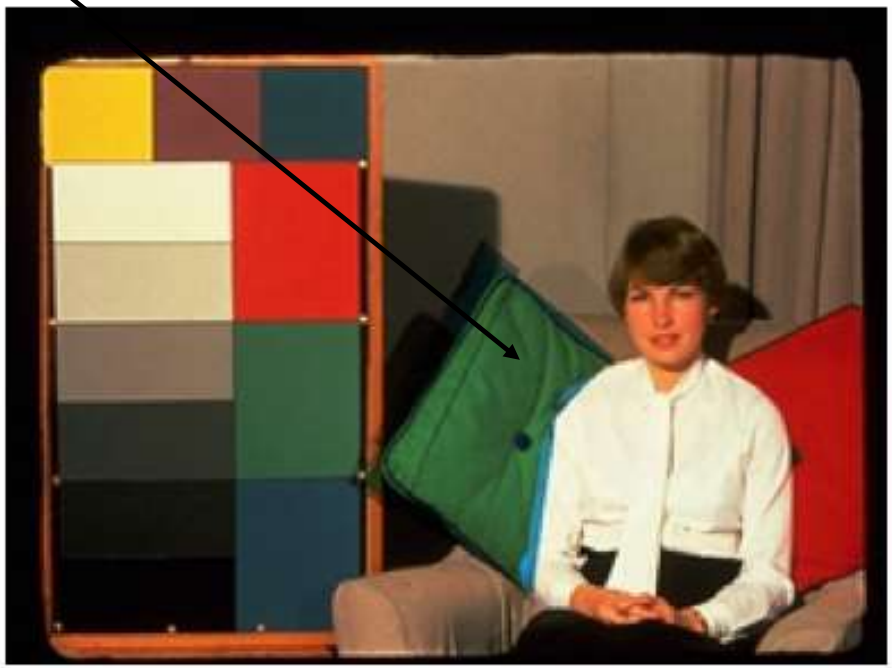
Color constancy

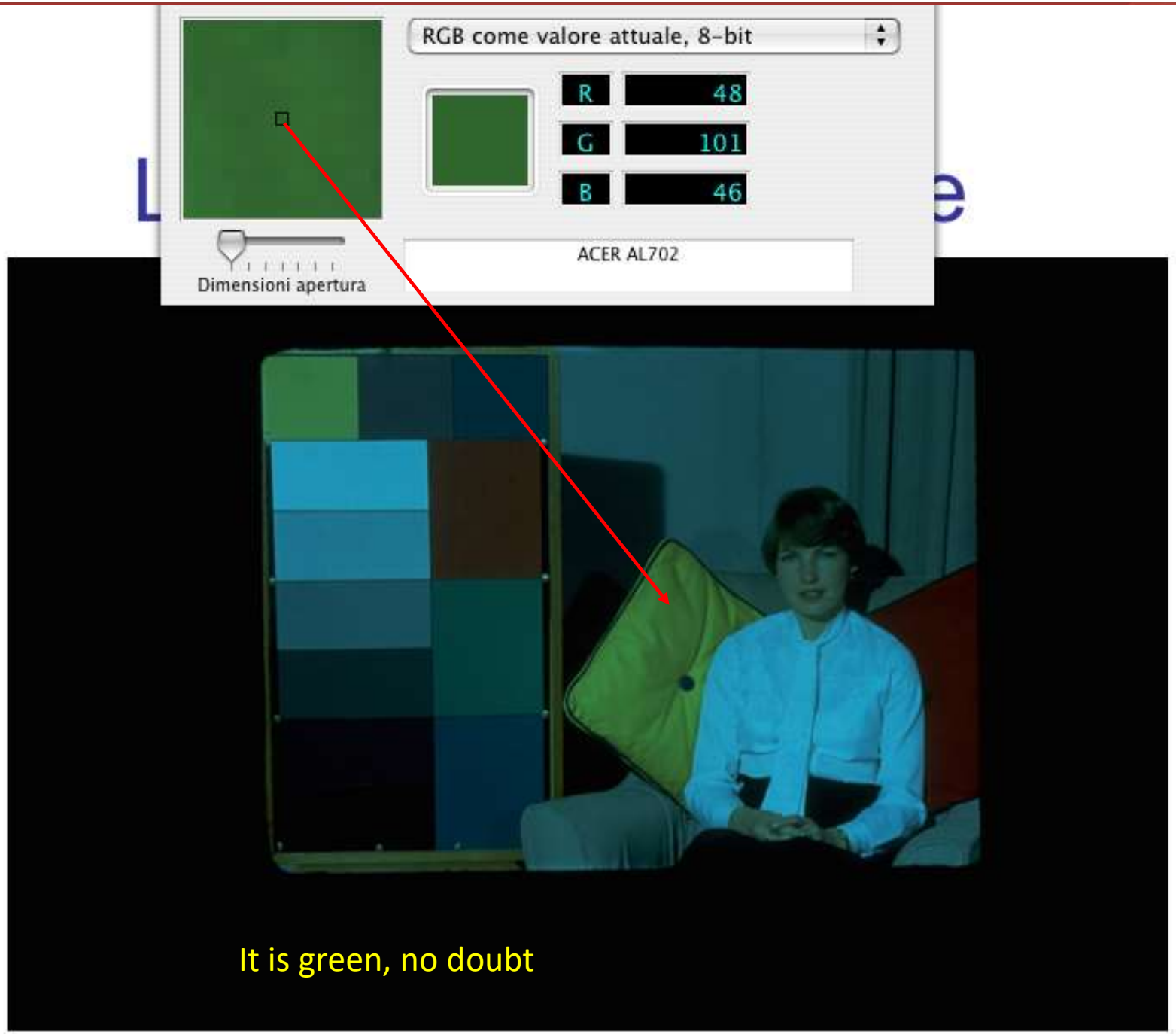

RGB come valore attuale, 8-bit
R
246
G
167
B
9
ACER AL702
Dimensioni apertura

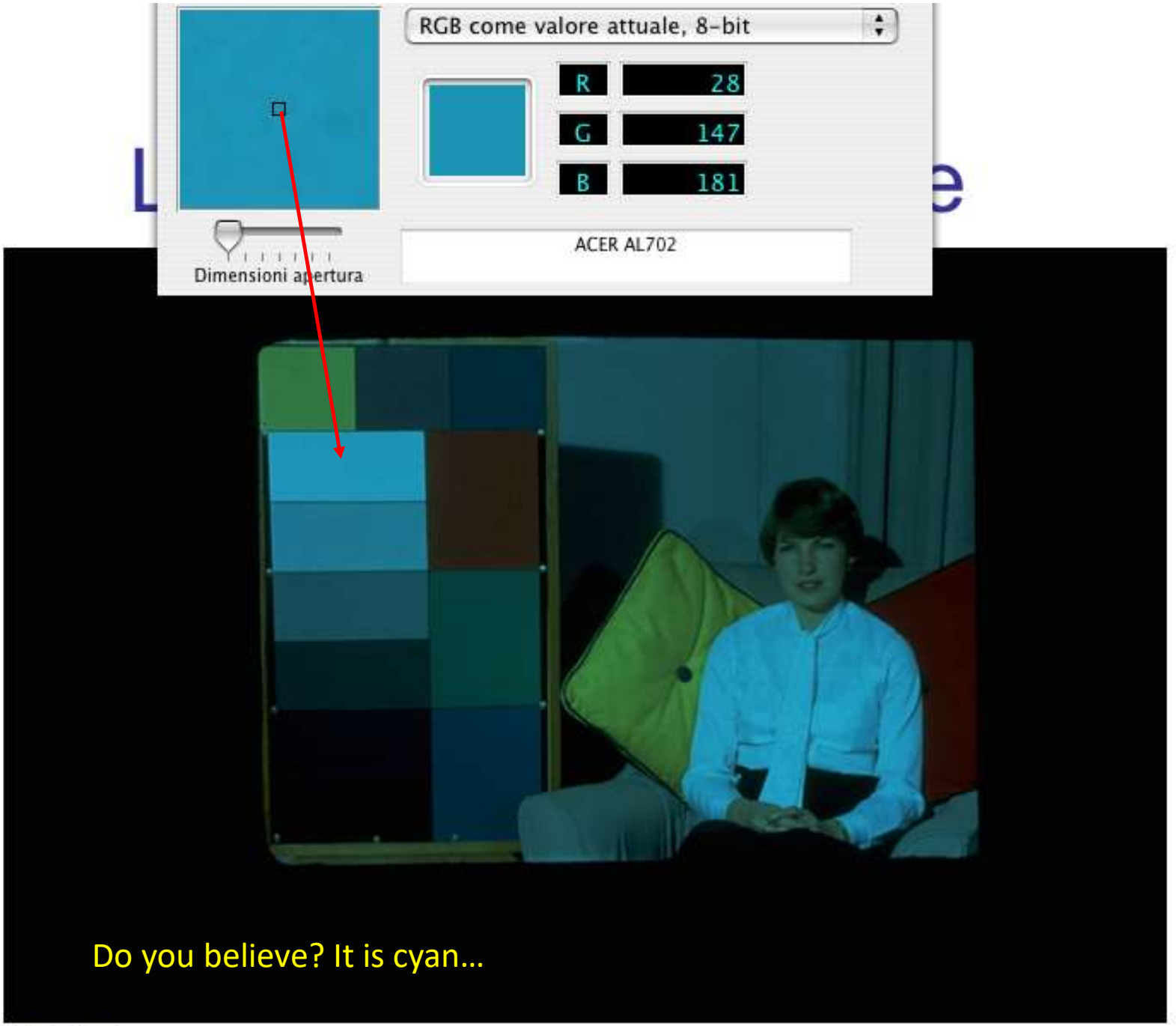



RGB come valore attuale, 8-bit
R
52
G
97
B
53
Dimensioni apertura
ACER AL702



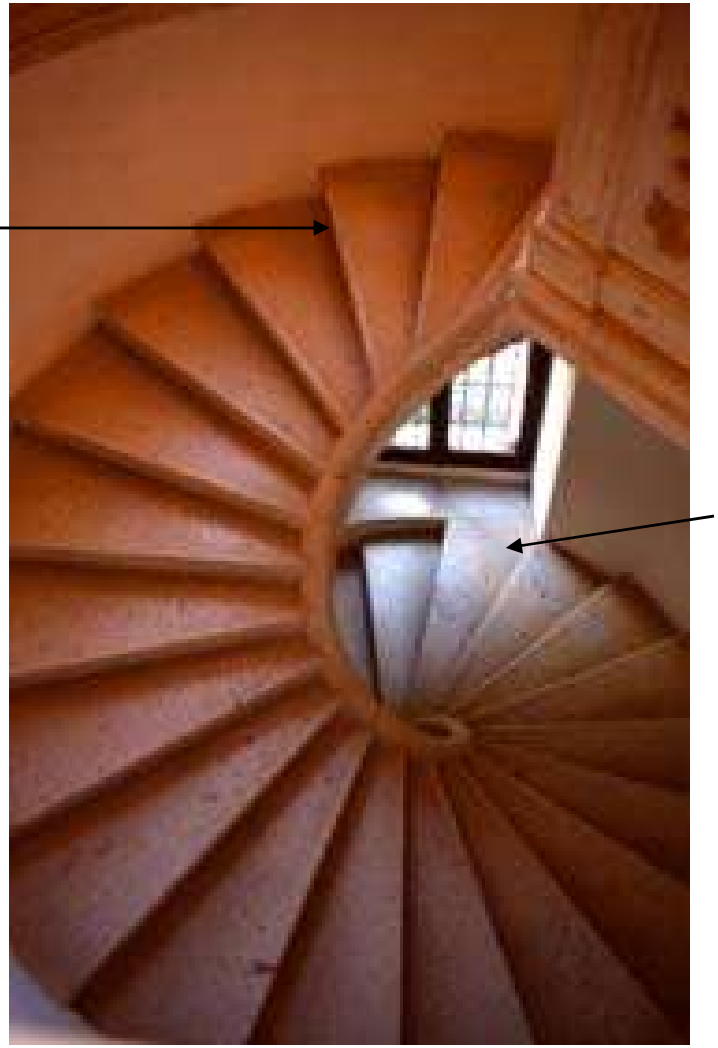



RGB come valore attuale, 8-bit
R 48
G 101
B 46
Dimensioni apertura
ACER AL702
It is green, no doubt


RGB come valore attuale, 8-bit
R
28
G
147
B
181
ACER AL702
Dimensioni apertura
Do you believe? It is cyan…

Color constancy

Appears red

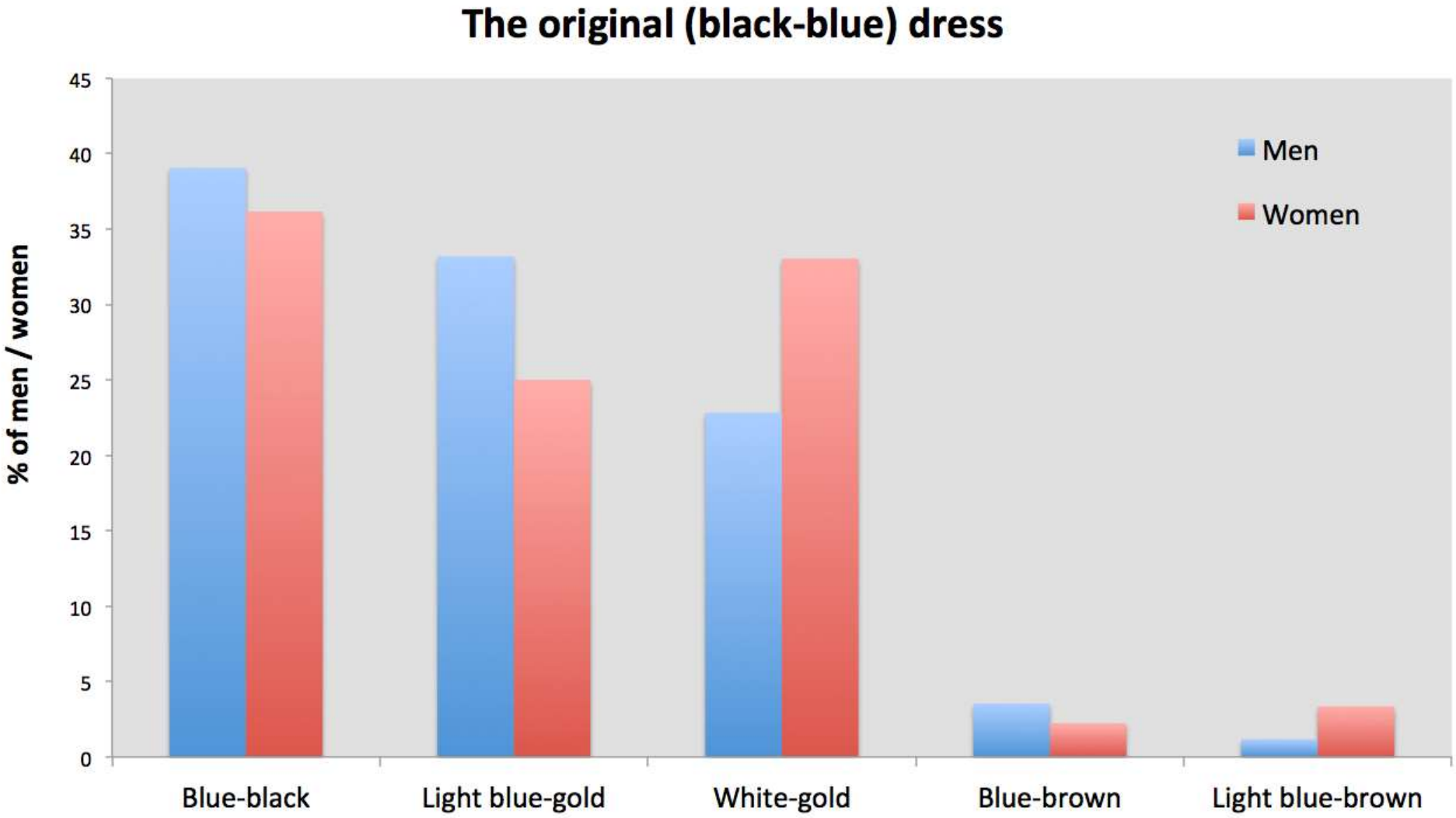


Appears white-bluish

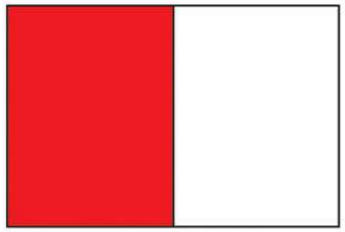
Same color, different perception?

#thedress
March 2015

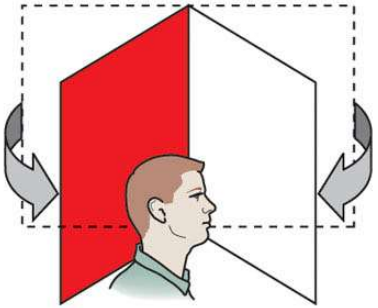
Kuvankappaus data



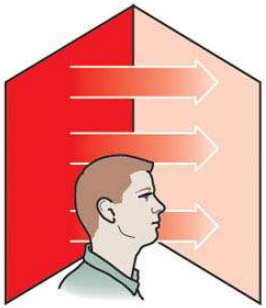
Esperimento di Bloj, Kersten, and Hurlbert



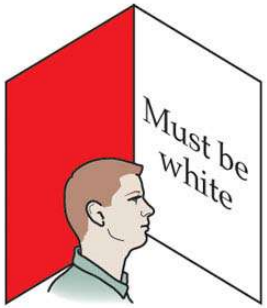
1. Start with a card half red, half white.



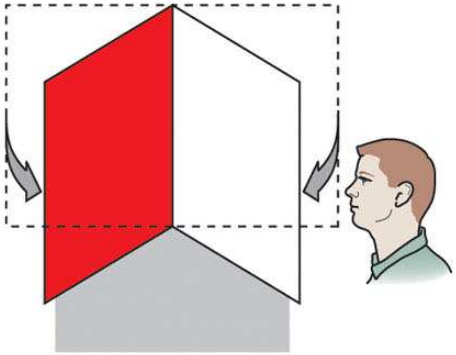
2. Fold it so that red faces white.



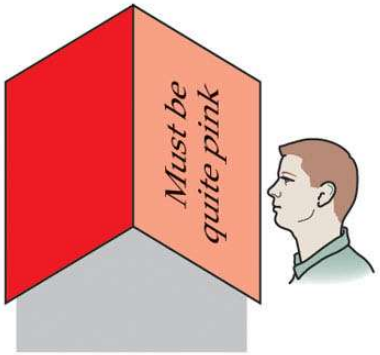
3. Light reflects from red onto white.



4. The visual system "knows" about the reflection and knows to discount it.

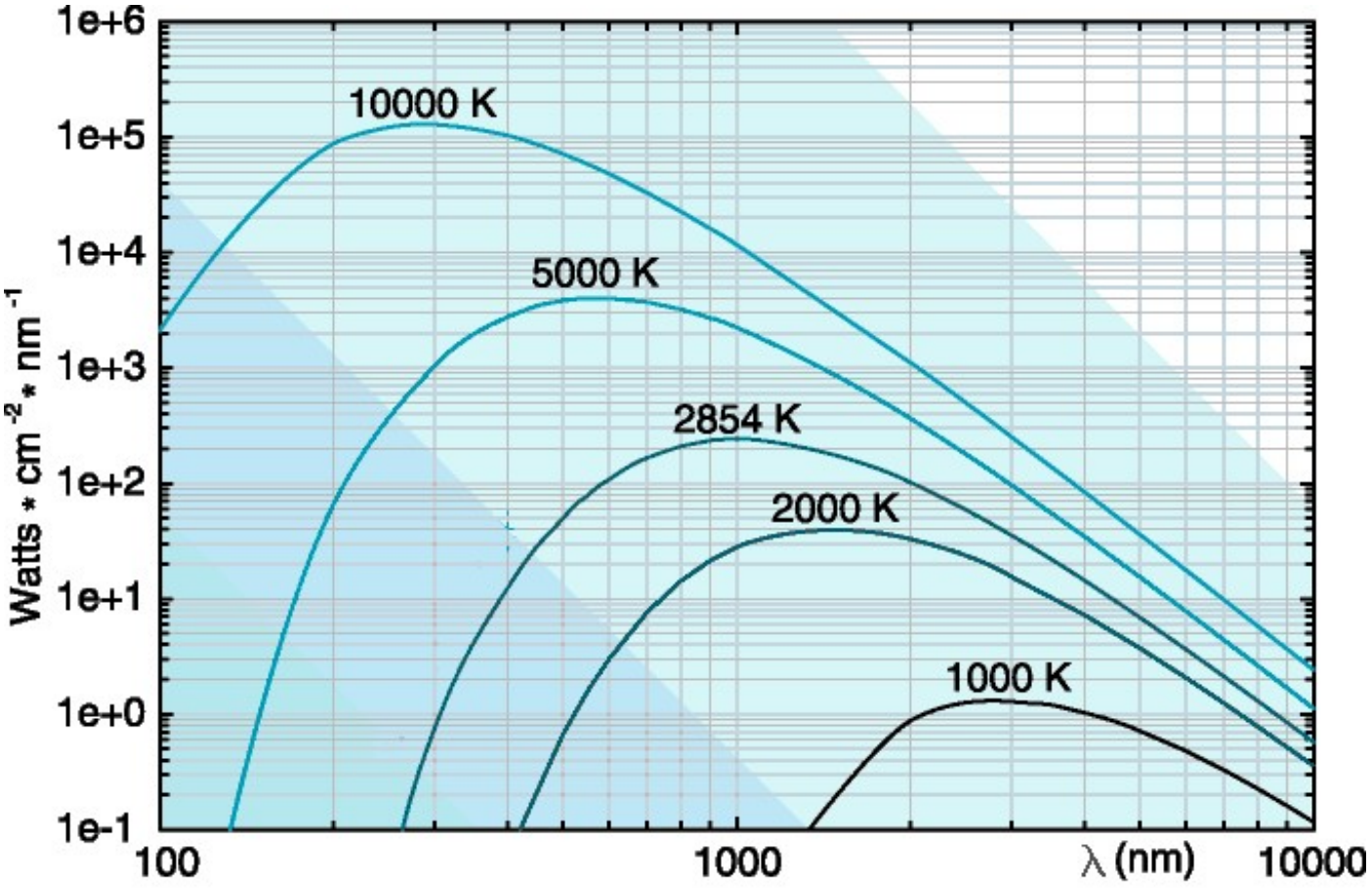


5. Now, fool the visual system into thinking the card is folded like a roof.



6. Without the reflection explanation, the white side now looks quite pink.

Black body


1e+6
1e+5
1e+4
1e+3
1e+2
1e+1
1e+0
1e-1
Watts * cm -2 * nm -1
10000 K
5000 K
2854 K
2000 K
1000 K
100
1000
λ (nm)
10000

Color temperature

When the light of a radiator has the same chromaticity coordinates as a blackbody at temperature T, the radiator has color temperature T

Correlated color temperature: when the chromaticity of a radiator is not equal to any of the chromaticities of a blackbody radiator

Question

Is a candle a cold or a hot light source? Has It a low or high color temperature?

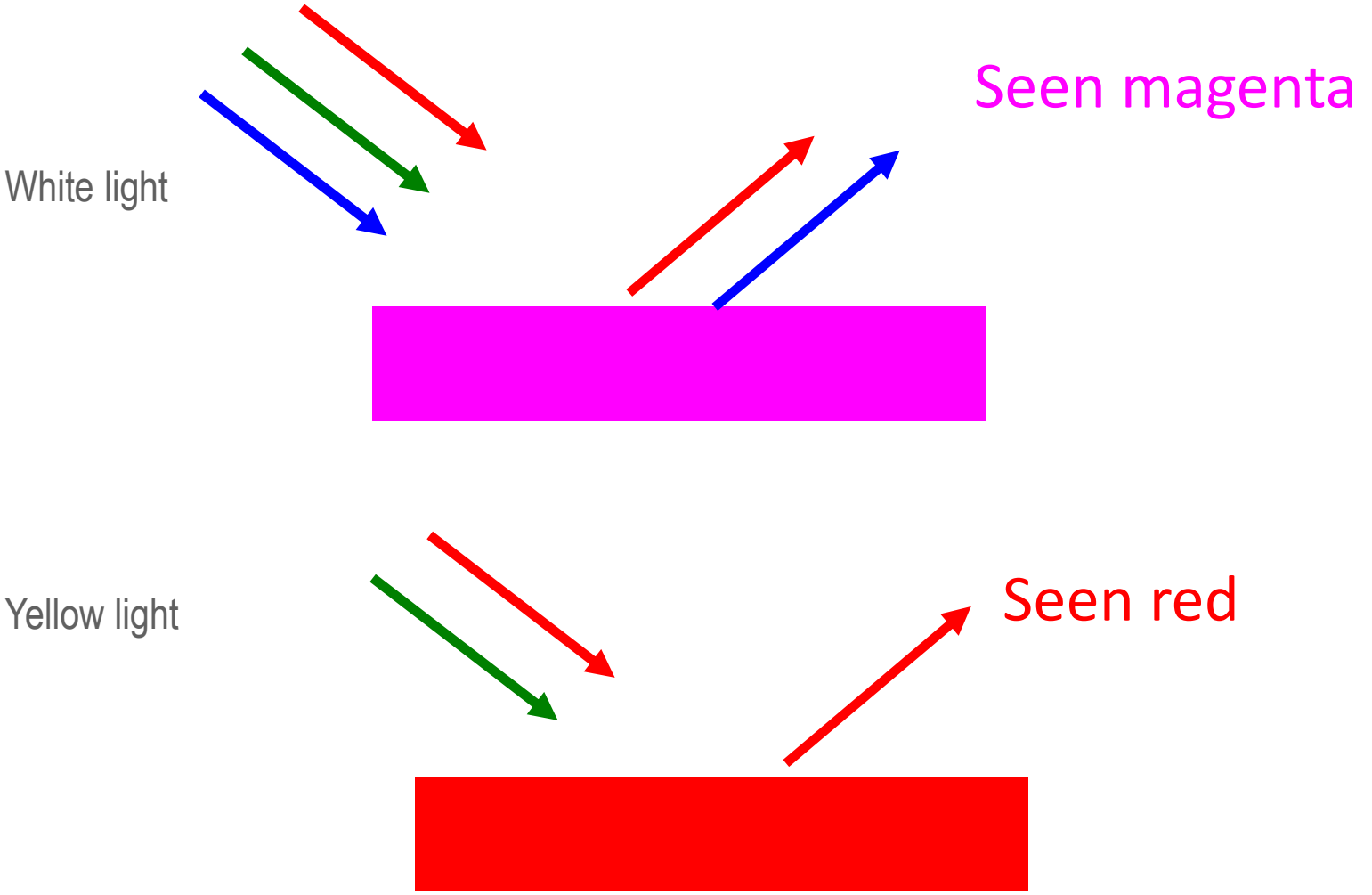
A candle is a hot source (psychologically speaking) and it has a low color temperature (physically speaking)

Color rendering index

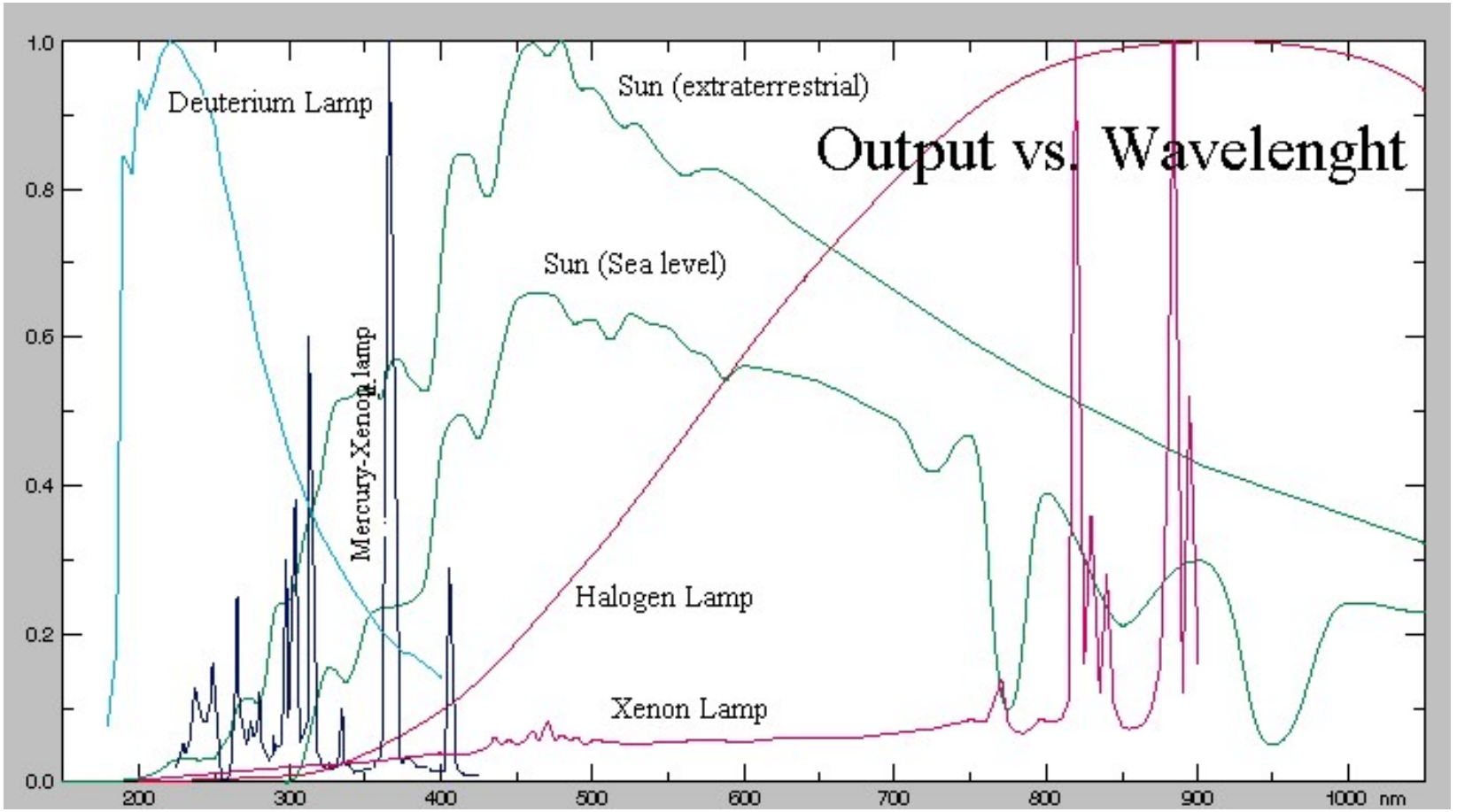
Color rendering of a light source is the effect the source has on the color appearance of objects in comparison with their appearance under a reference source.

For calculating the CIE CRI a set of eight test-color samples is specified.

Light and color



Nothing like the sun?

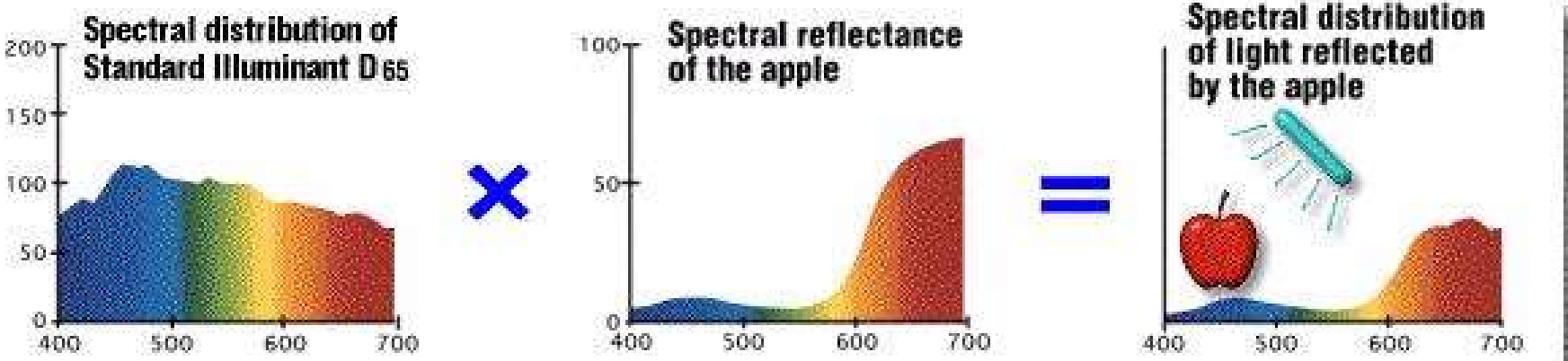


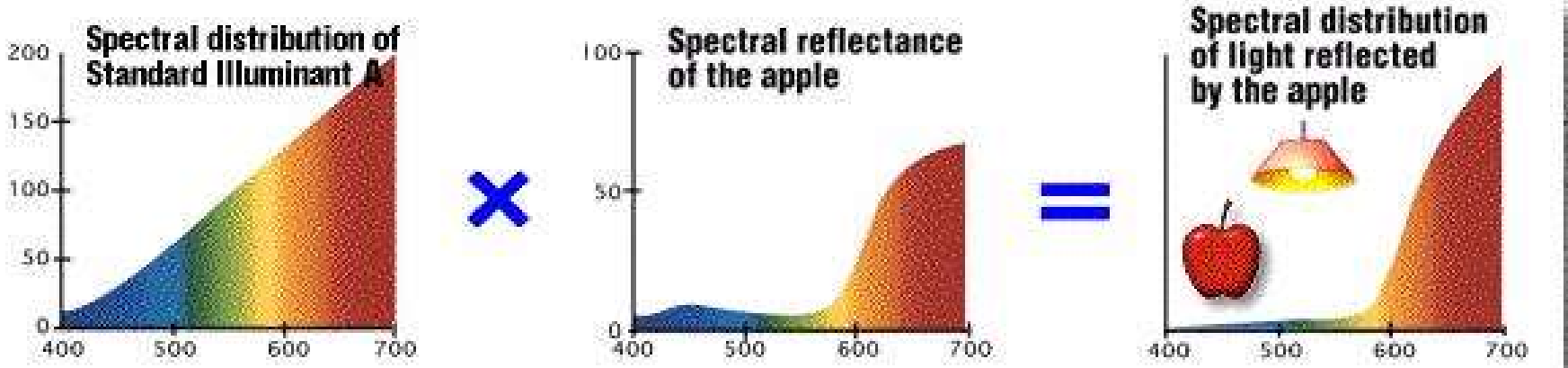
It’s strange but…

in a sense

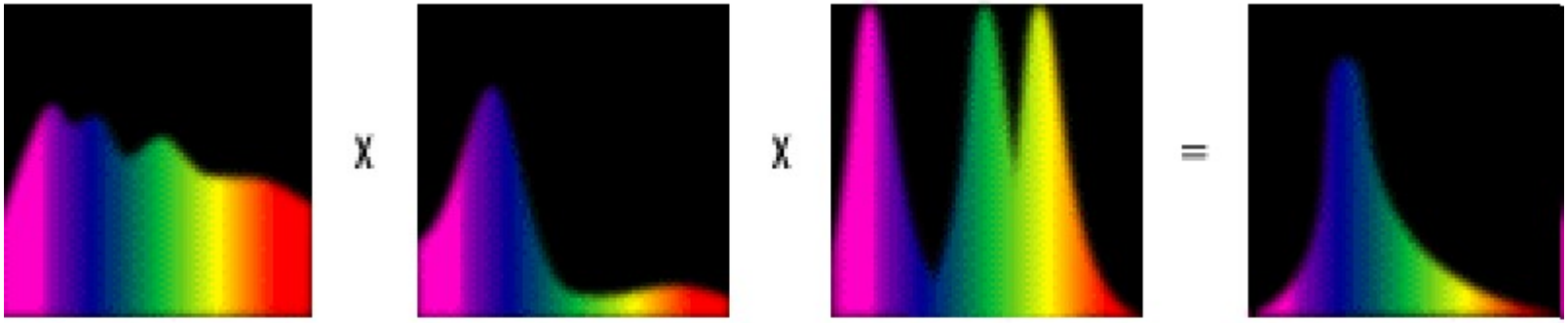
Color doesn’t exist

For convenience we may talk about a yellow light, but we really should say “a light that we perceive as yellow” In fact light of a variety of different spectral compositions can evoke the same color perception





When we see a color……



Light and art: experiments

Aim of the experiment

Evaluating subjective preferences regarding lighting in front of a painting



Paintings selected for the experiment

"Madonna del Granduca"
Raffaello (1504)
Olio su tavola 84,4 X 55,9 cm

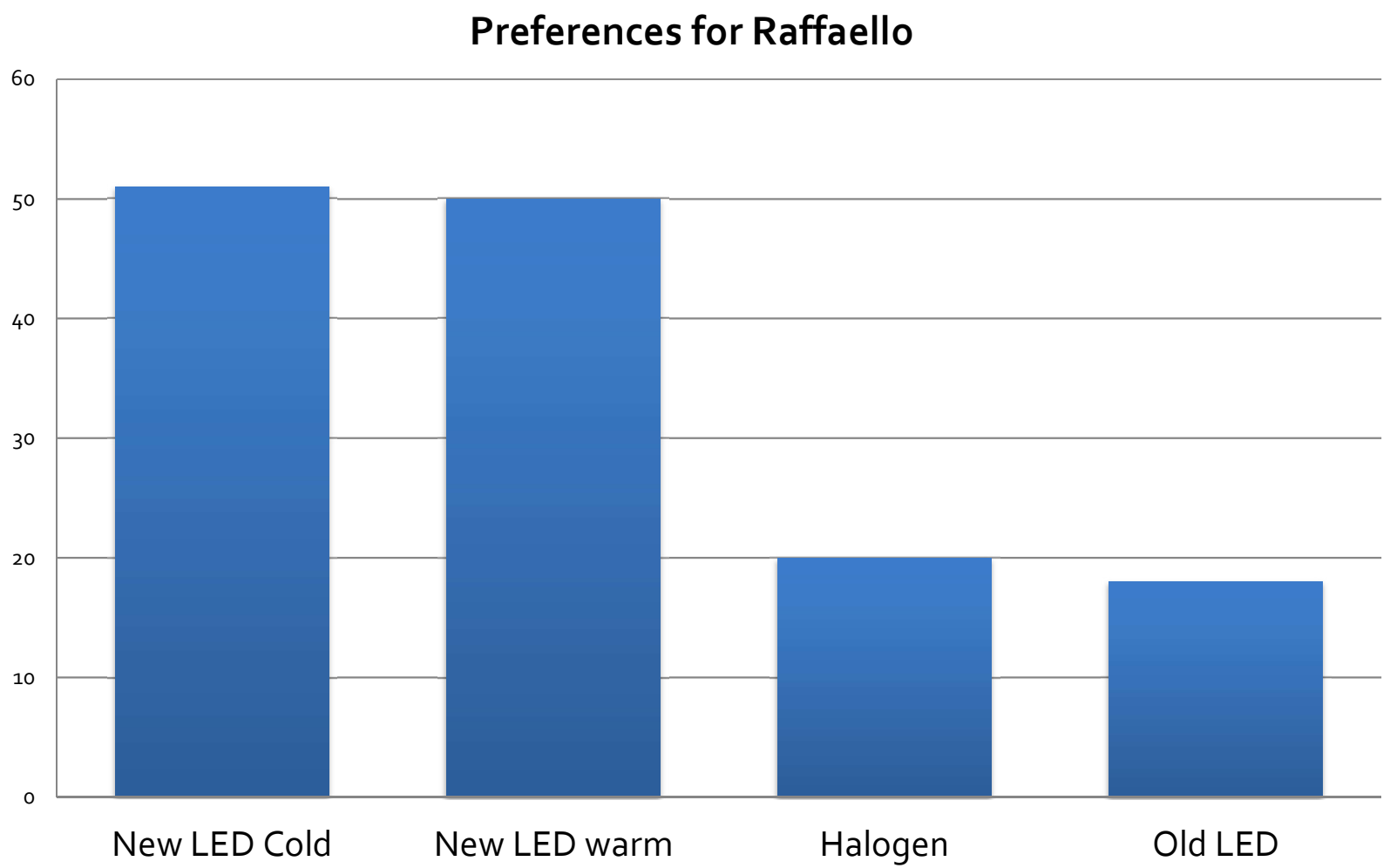
Paintings selected for the experiment

"Madonna del velo"
Anonimo (1500)
Olio su tavola 120 X 90 cm

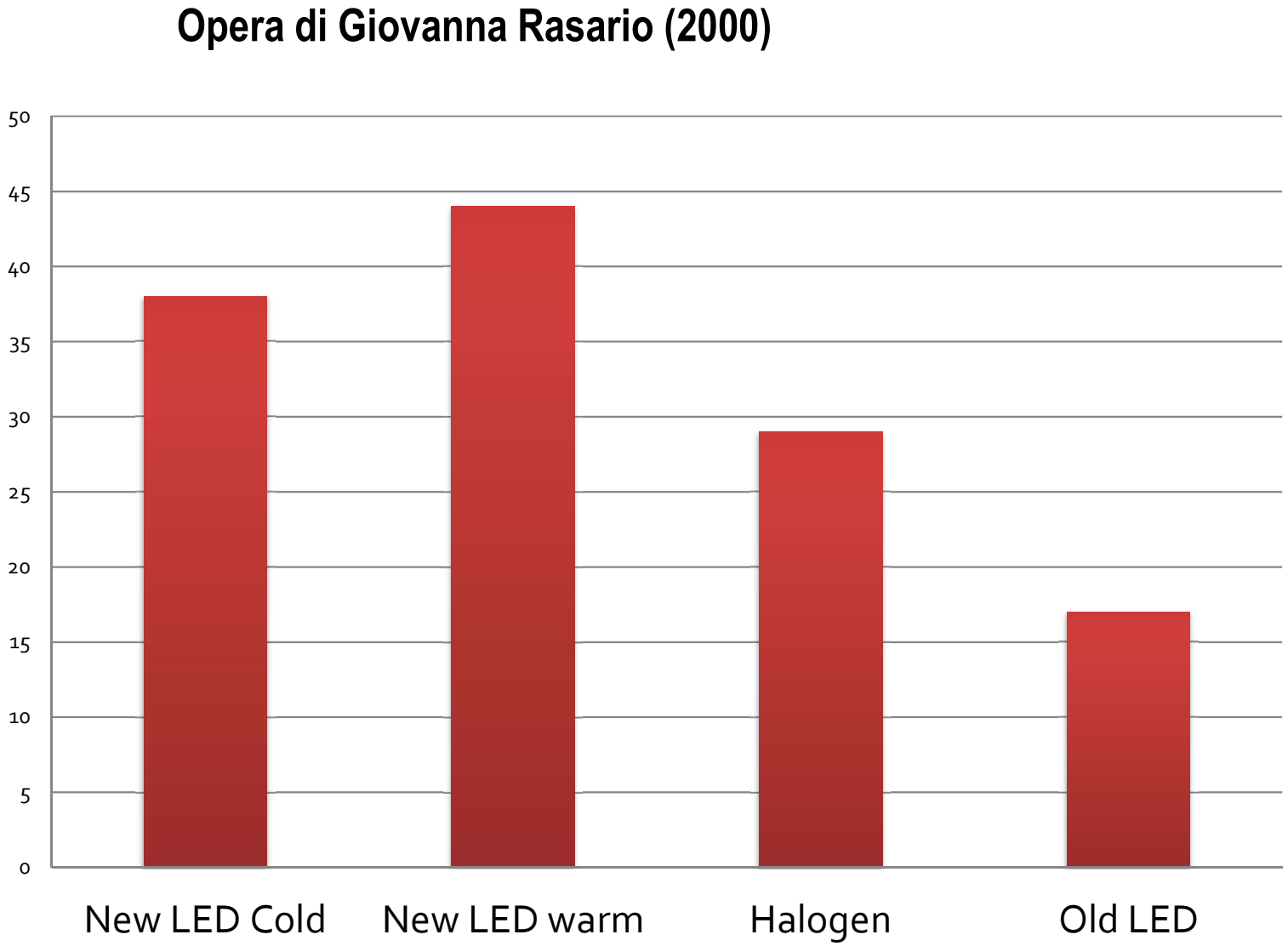
Paintings selected for the experiment

"L'Assoluto della luce"
di Giovanna Rasario (2010)

Preferences



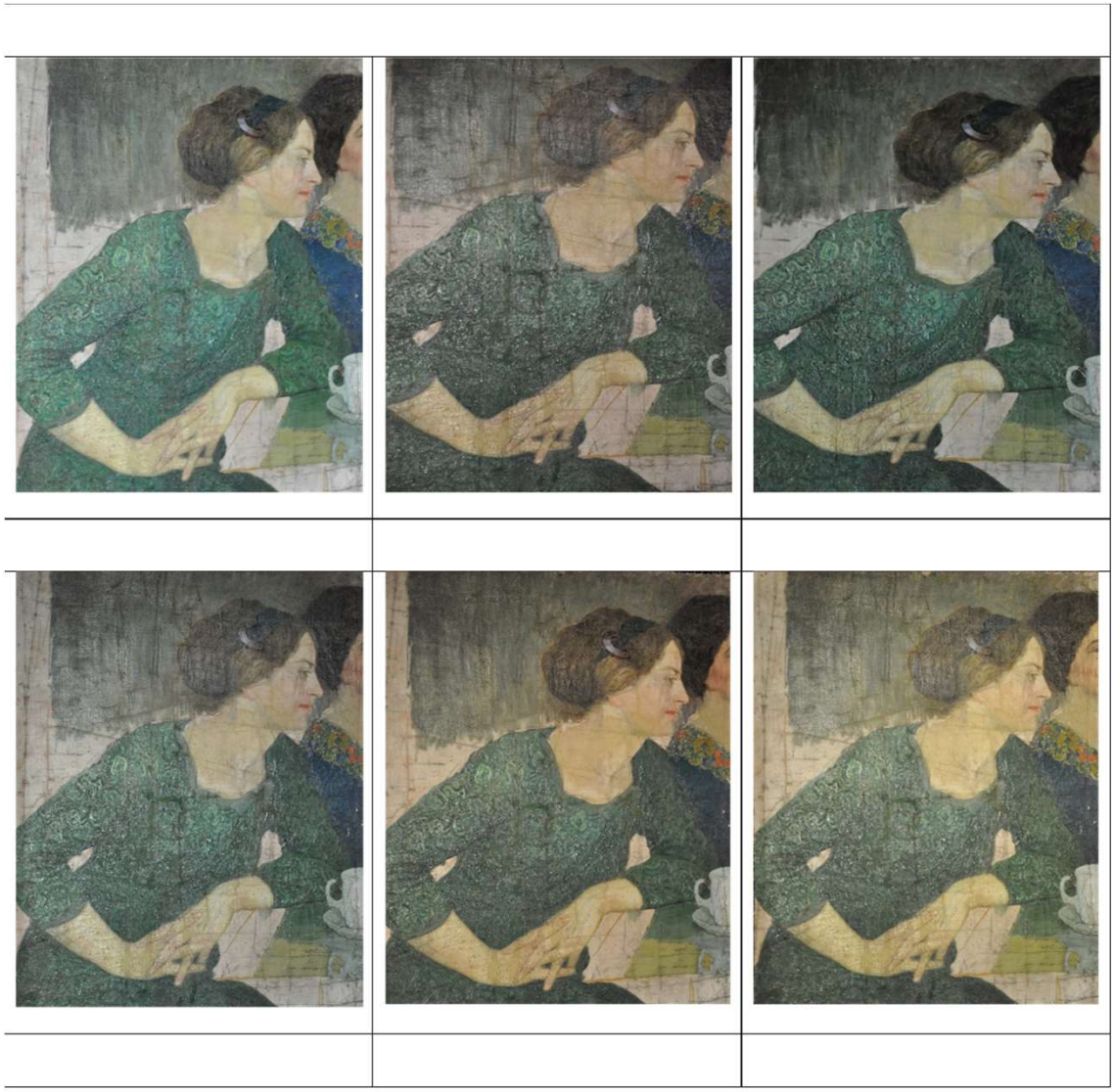
Lighting preferences



Measuring the inmeasureable

The experiment

Elizabeth Chaplin

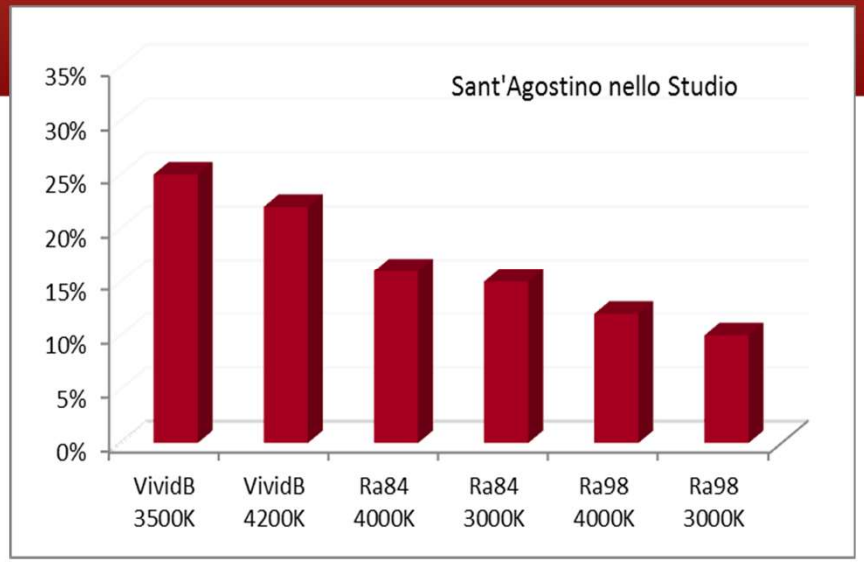


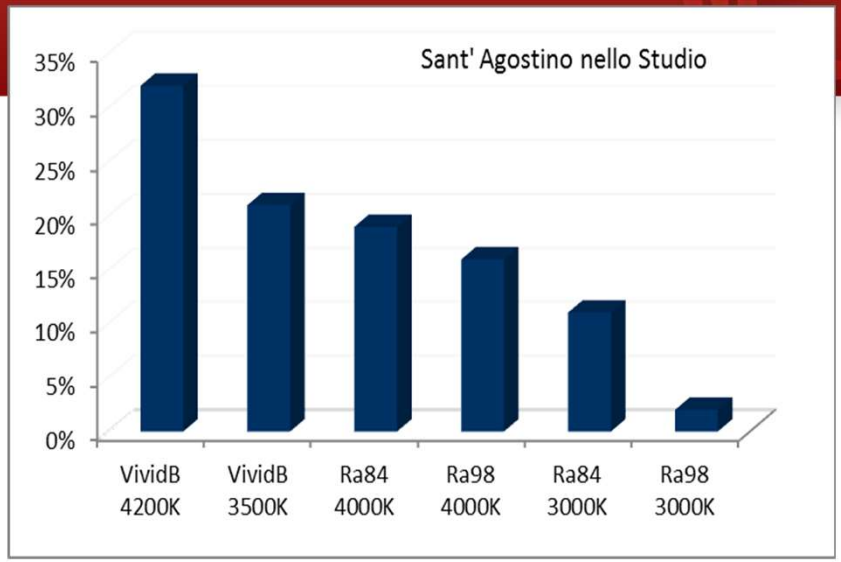
Botticelli

Giovanna Rasario

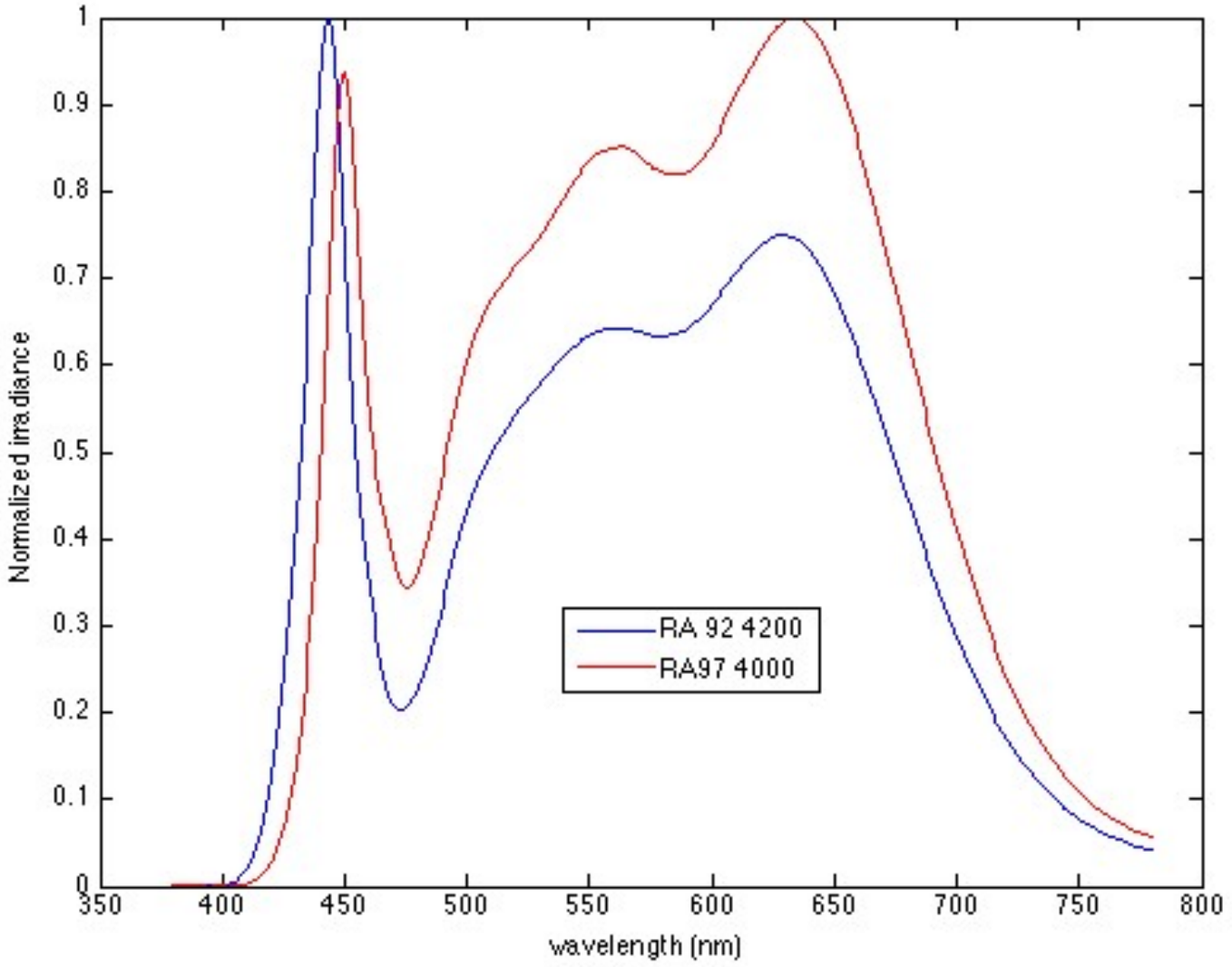




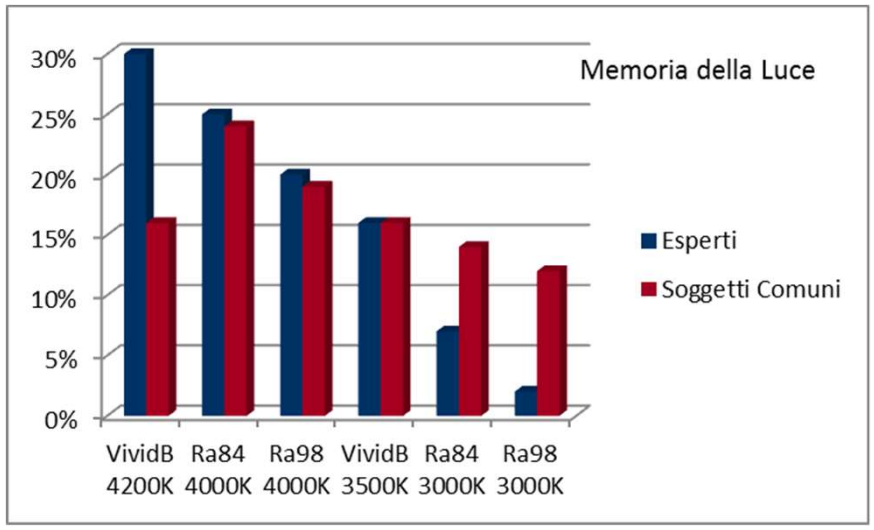


Sant'Agostino nello Studio
35%
30%
25%
20%
15%
10%
5%
0%
VividB 3500K
VividB 4200K
Ra84 4000K
Ra84 3000K
Ra98 4000K
Ra98 3000K

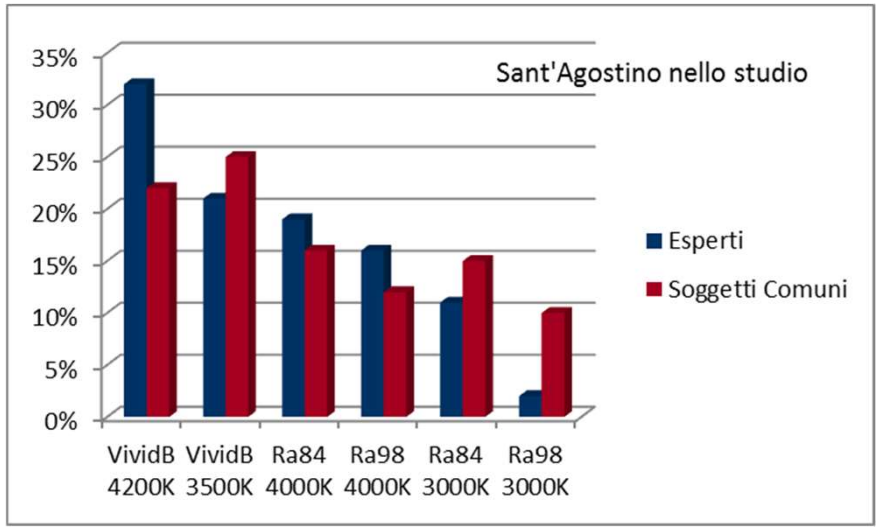

Sant' Agostino nello Studio
35%
30%
25%
20%
15%
10%
5%
0%
VividB 4200K
VividB 3500K
Ra84 4000K
Ra98 4000K
Ra84 3000K
Ra98 3000K

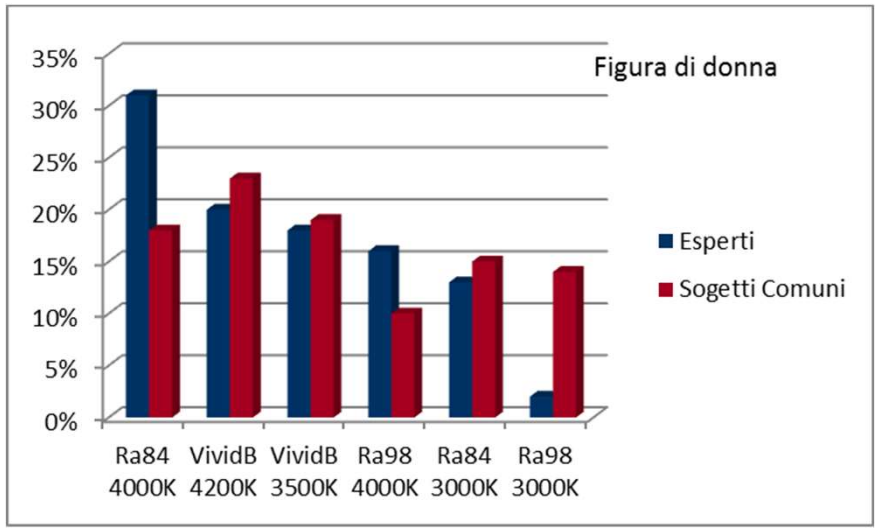
The champion and the worst

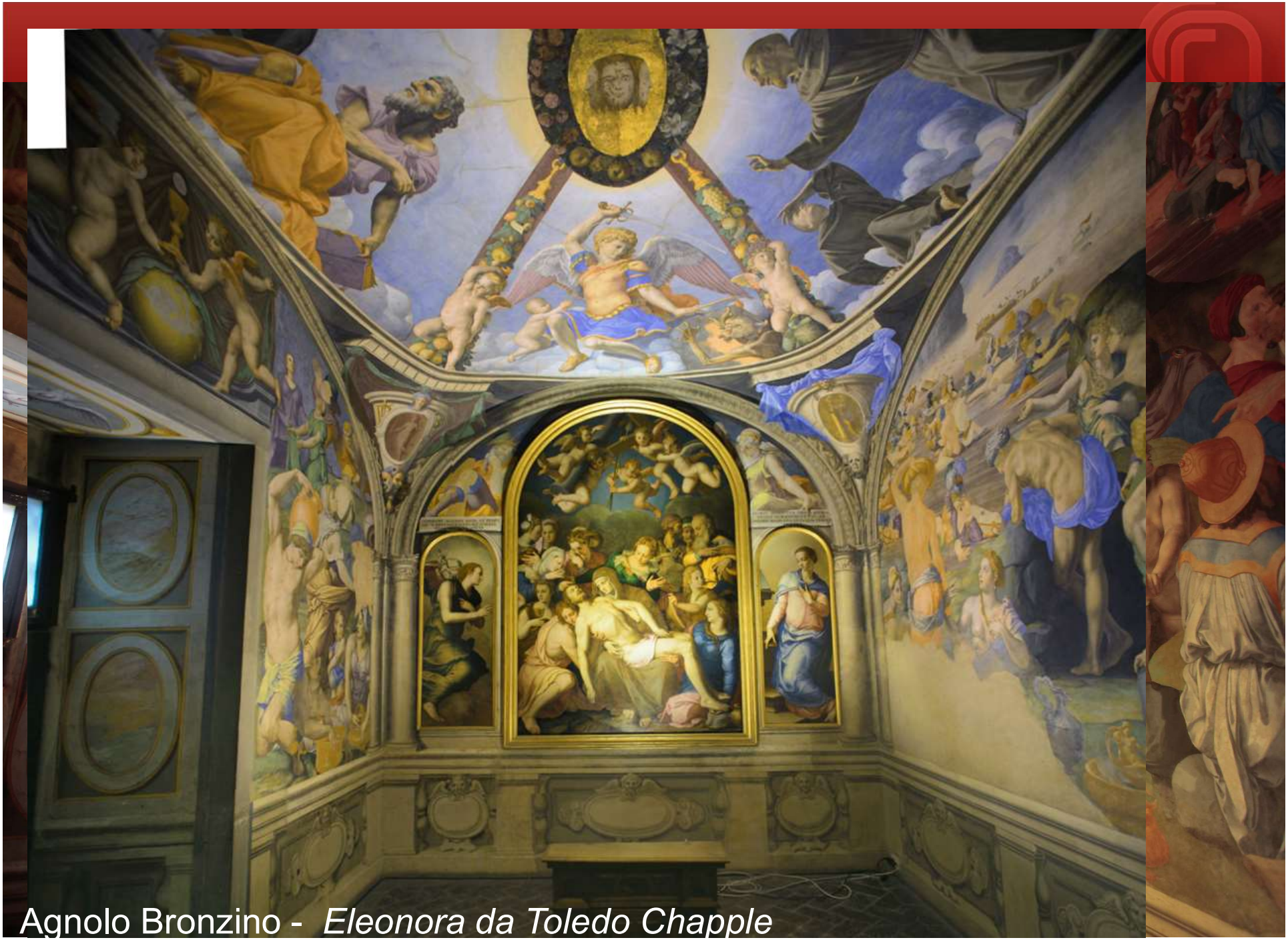


Expert or not









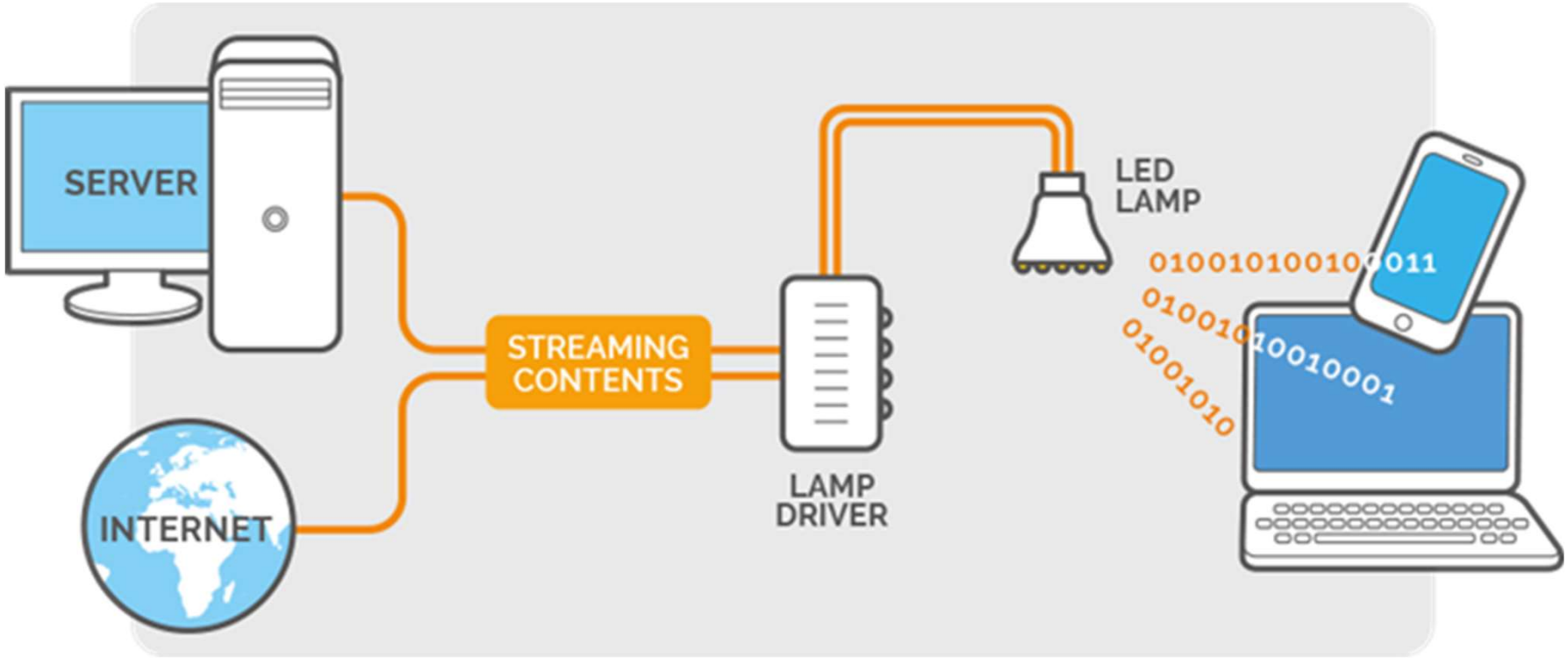
Agnolo Bronzino - *Eleonora da Toledo Chapple*


VISITATIO MARIA AD ELISABET

Relative damage

Sources	Relative damage
Open Window	100
Close Window	34
Close window with UV protection	9
Fluorescent lamp	9
Halogen lamp	3

Visible Light Communication



Measurements in textile museum (Prato)

Samples

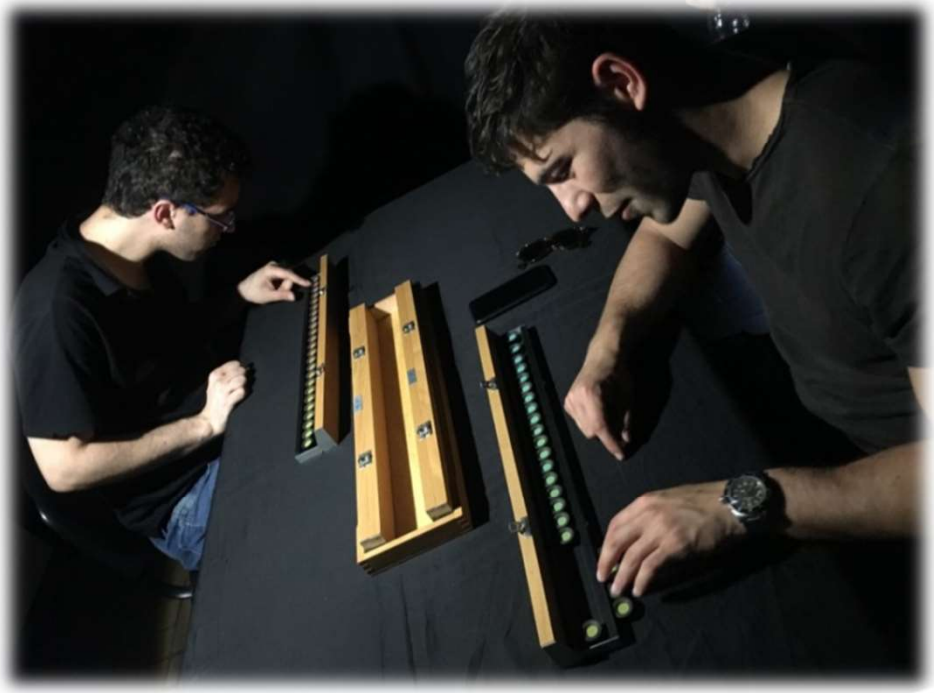
From movie "Marie Antoinette" (director Sophia Coppola) and from 1700 sample, (J. Claude Frères, Paris Mode Internationale Sélection Service Collection)

Color perception under LED

Experimental Setup

Frequenza di Clock impostata anche in questo caso a 96Hz

Esecuzione Farnsworth-Munsell 100 hue Color Vision Test



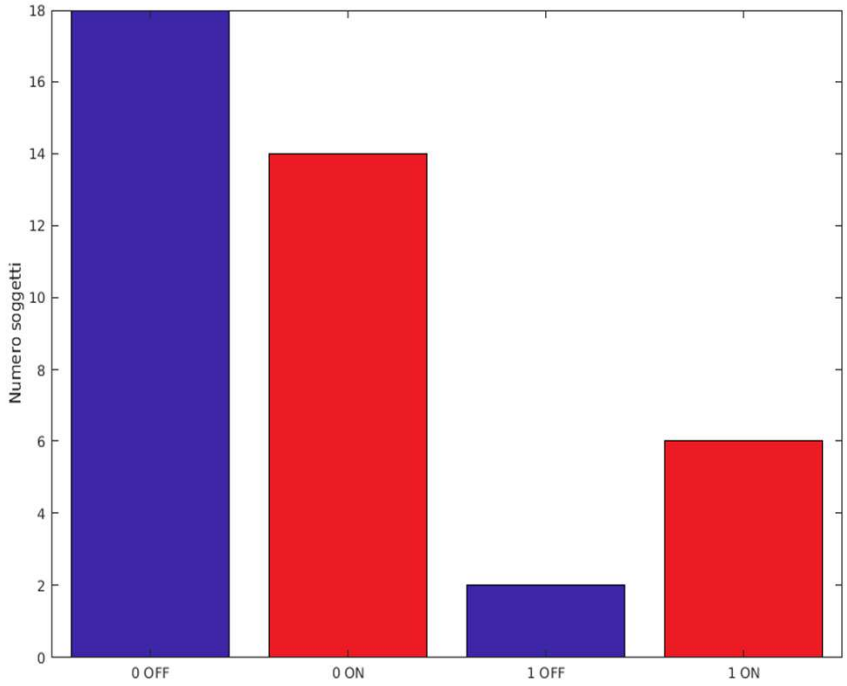
Campione di 20 utenti normovedenti e con le correzioni in uso indossate: ***11 donne*** *e* ***9 uomini****, di età comprese tra i* ***20 e i 65 anni*** *e provenienti da luoghi di lavoro diversi*

Color perception under LED

Ishihara Test e City university colour vision Test

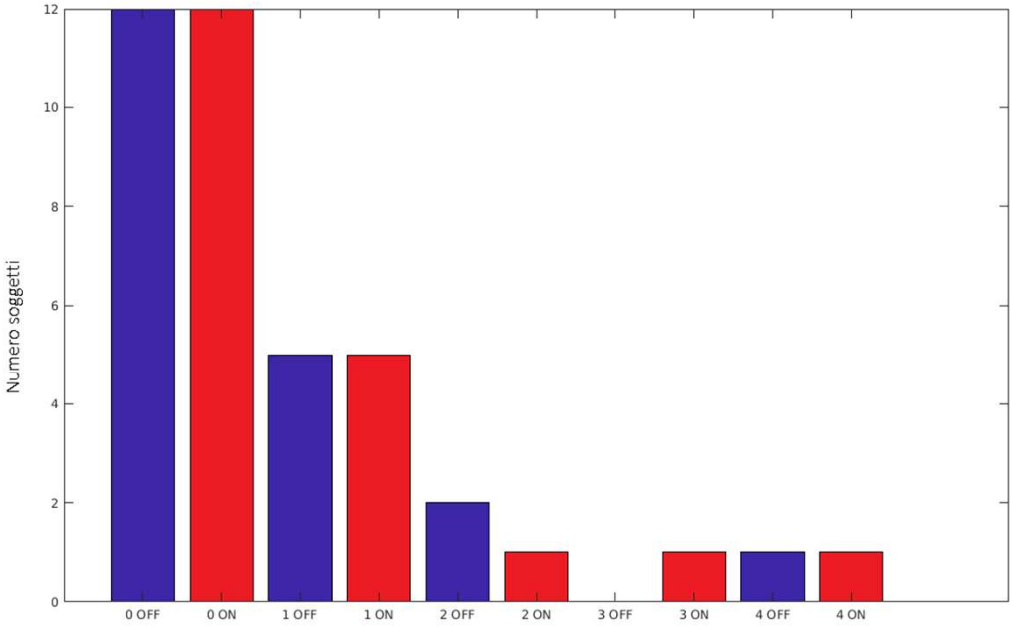
Some results

Ishihara Test e City university colour vision Test



Istogramma relativo all'Ishihara Test

Istogramma relativo al City University Colour Vision Test (CUT)



Farnsworth-Munsell 100 Hue test

Some results

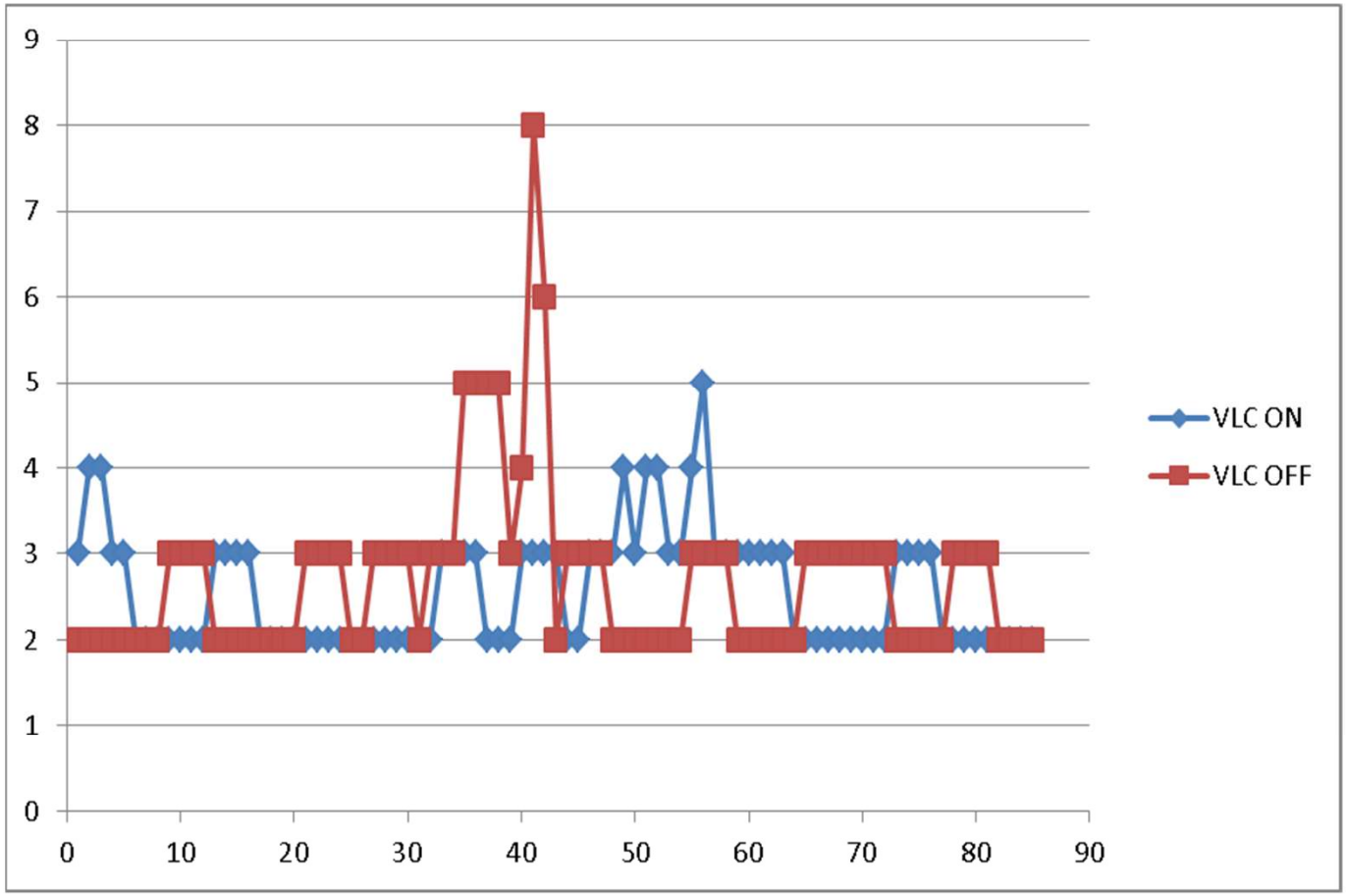


Grafico a dispersione Farnsworth-Munsell 100 hue Color Vision Test (Paziente n°3)

Riferimenti

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