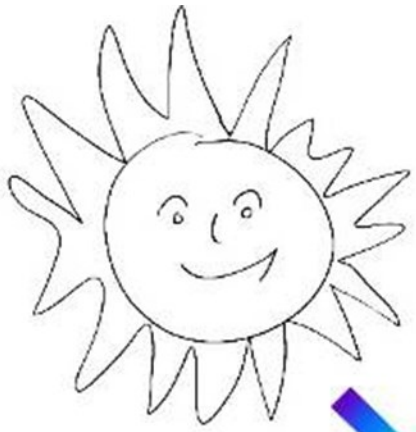
Interface between outside and inside
Can we trust our eyes?

13. BYK-Gardner User Meeting

Bad Tölz 9. -10. Mai

Werner Rudolf Cramer

Outside & inside



Light transmitter sun

Light receiver eye

Light processor brain

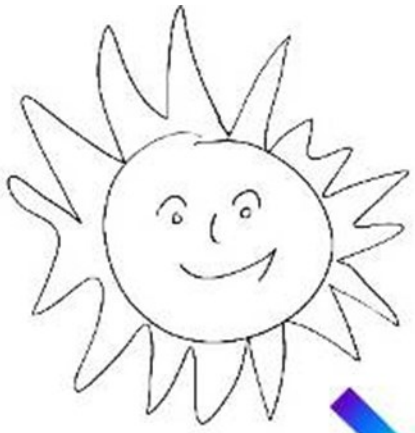
Light manipulation

Physics

Physiology

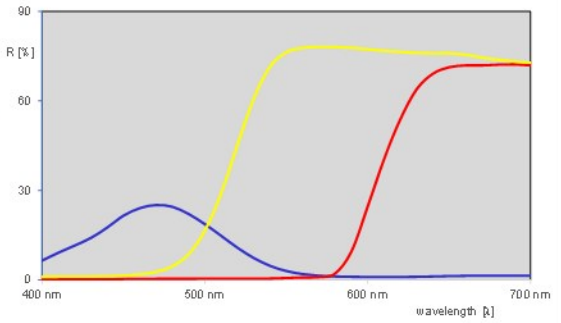
Psychology

Outside

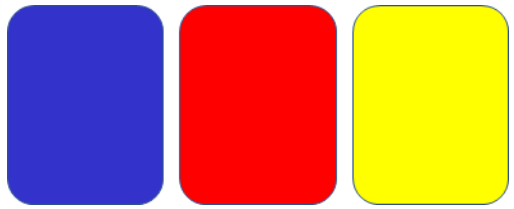


Light source

Light receiver BYKmac



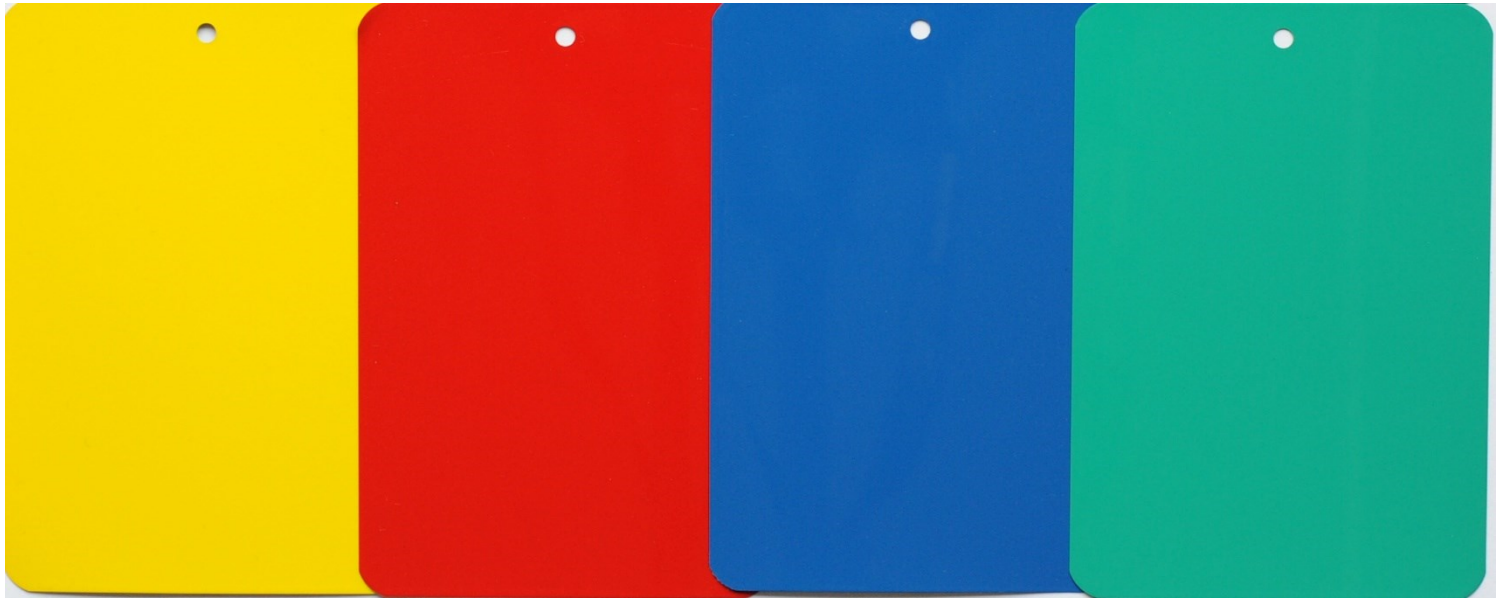
Reflectance curve



Light manipulation

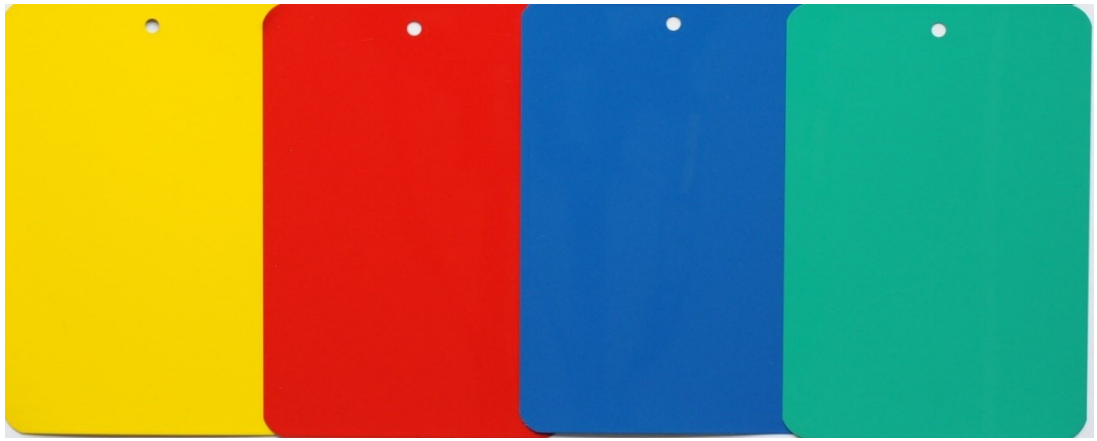
Physics

Outside: we see color

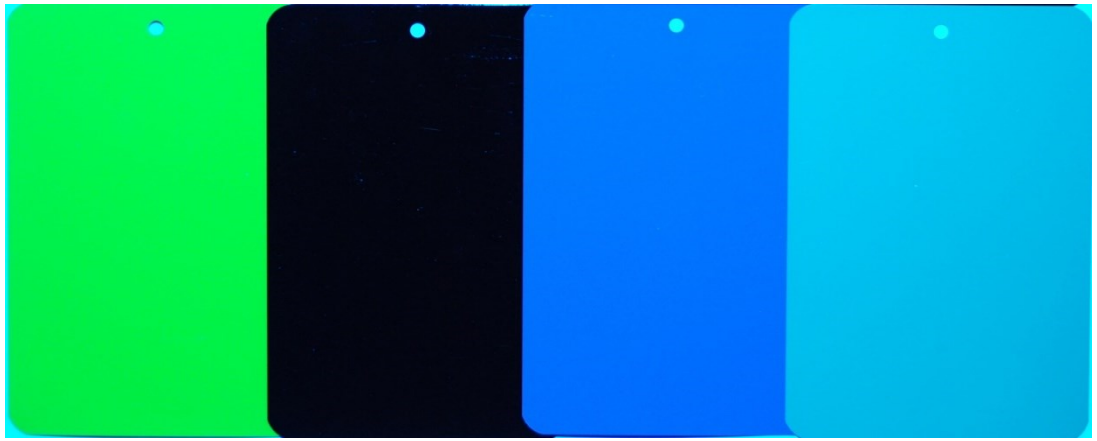


- We open our eyes and see colors as a matter of course
- We see yellow, red, blue and green and many other colors
- This self-evidentness prevents us from thinking about the colors themselves, their origin etc.
- We also believe that what we see corresponds to reality. (WYSIWYG)
- But: Is this really so? Is reality real?

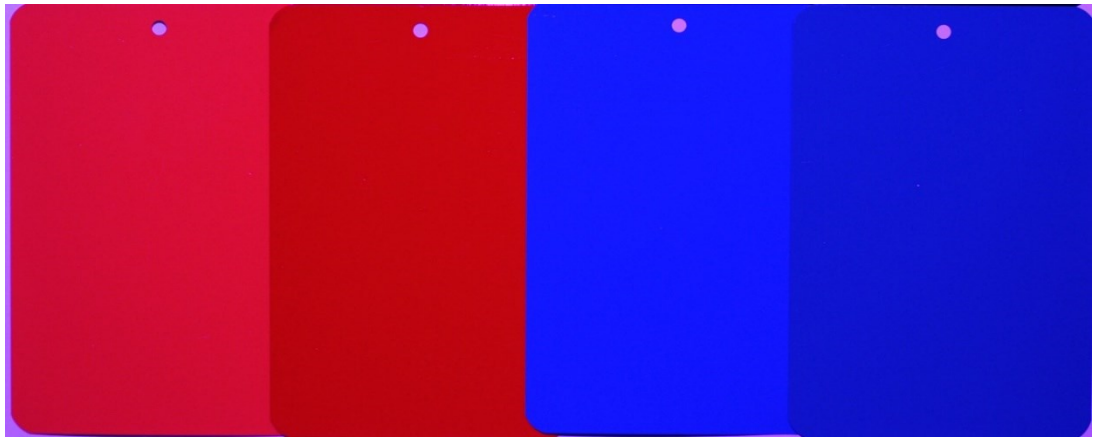
Outside: Different colors?



White light



Turquoise light

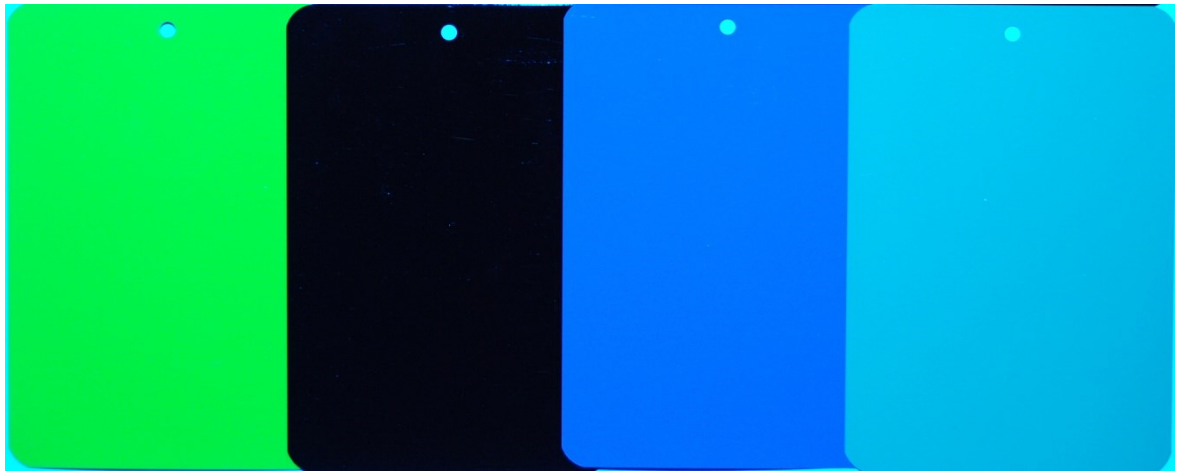


Purple light

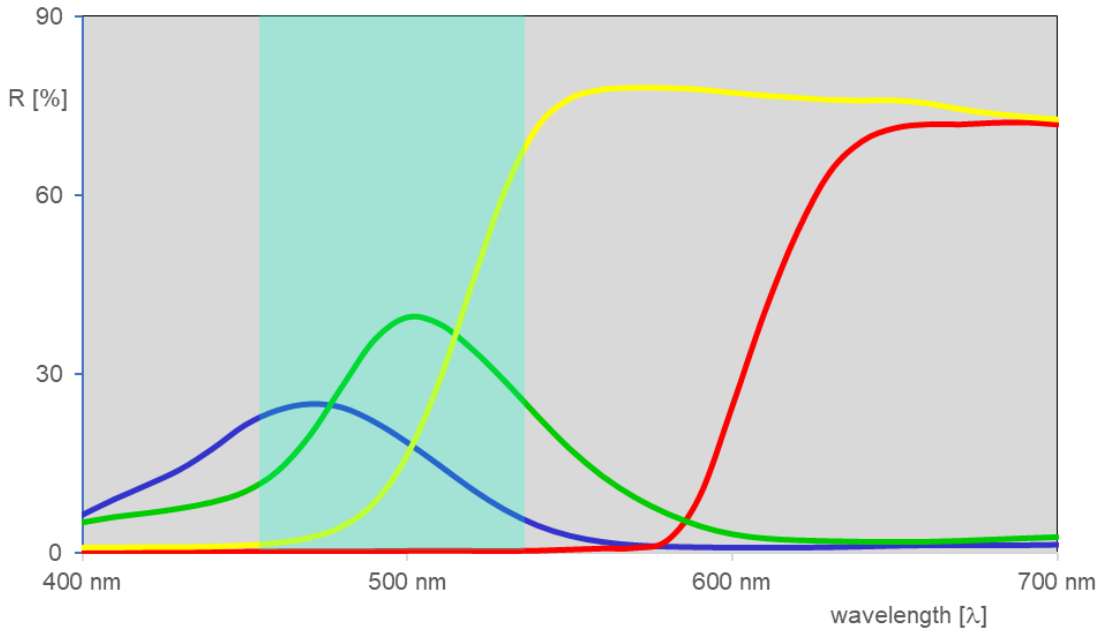
Red light

Different lights create different colors

Outside: Turquoise light



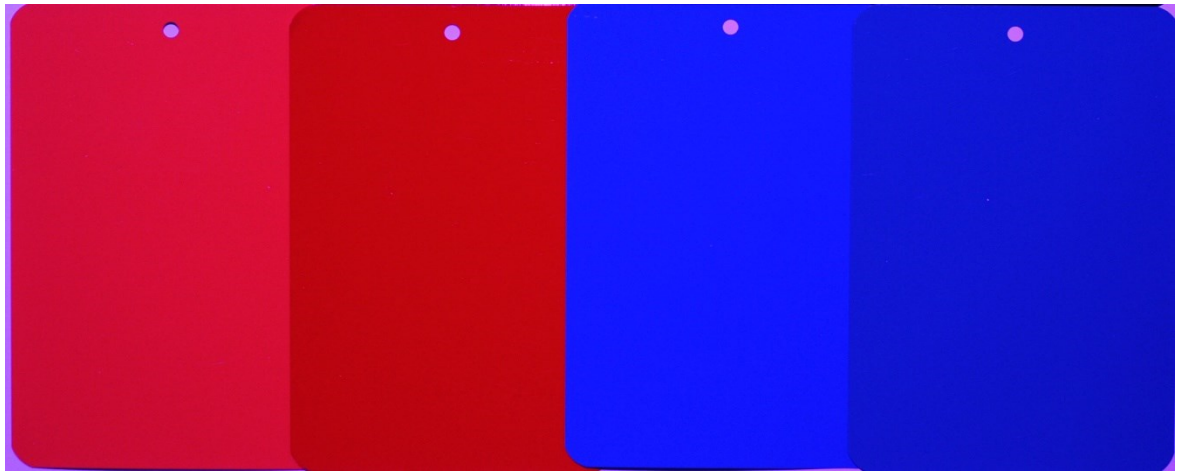
Turquoise light



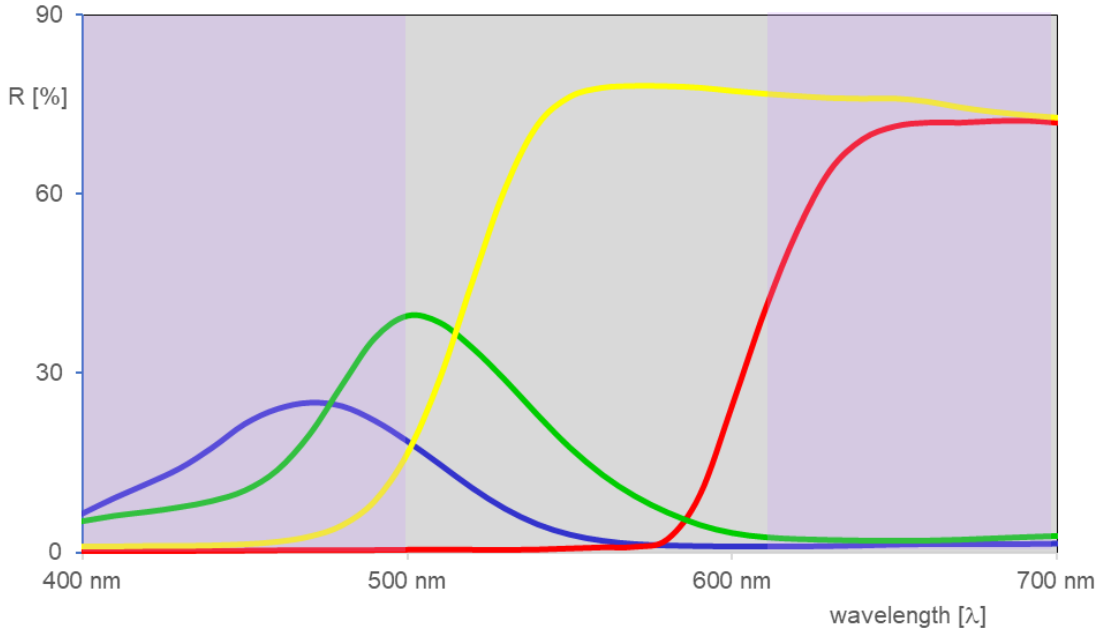
Turquoise light:

- Yellow reflects only in the green spectral range,
- Red does not reflect,
- Blue reflects in the blue range,
- Green reflects in the blue range.

Outside: Purple light



Purple light

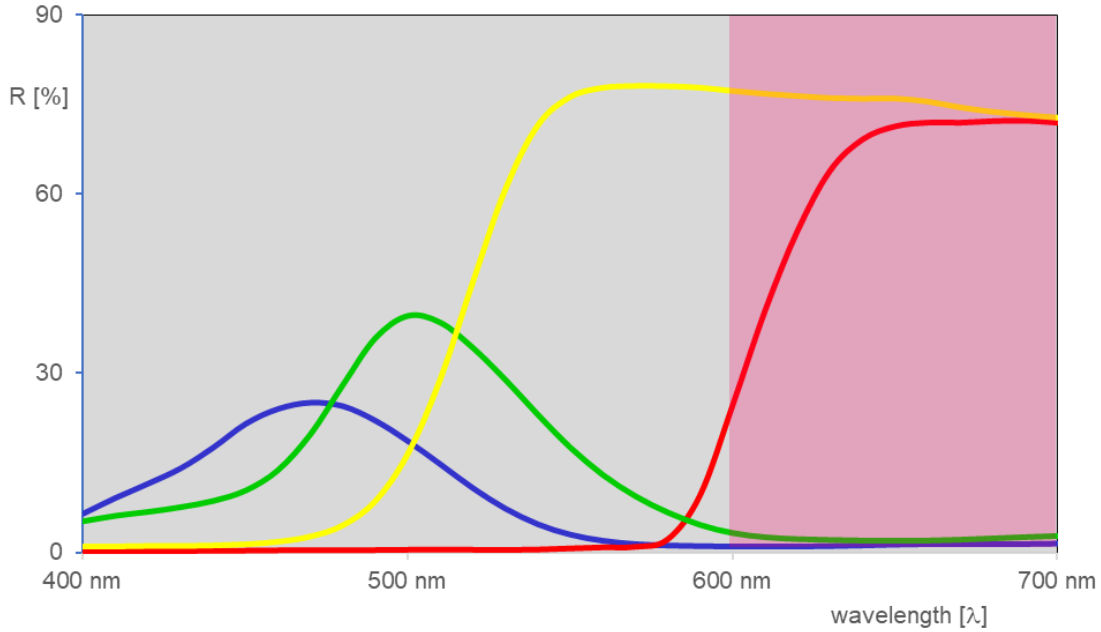


Violet light:

- Yellow reflects only in the red spectral region,
- Red reflects in the red spectral range,
- Blue reflects in the blue spectral range,
- Green reflects only in the blue range.

Outside: Red light

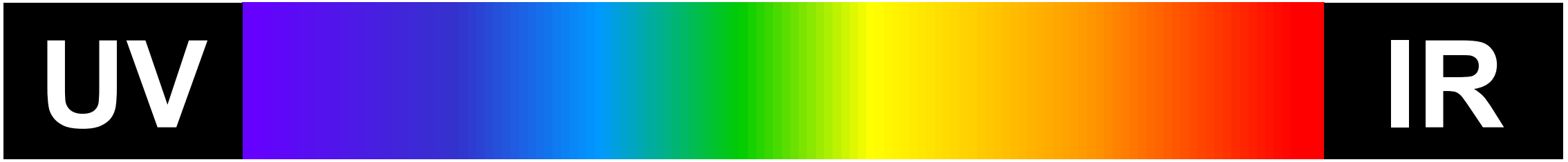
Red light



Red light:

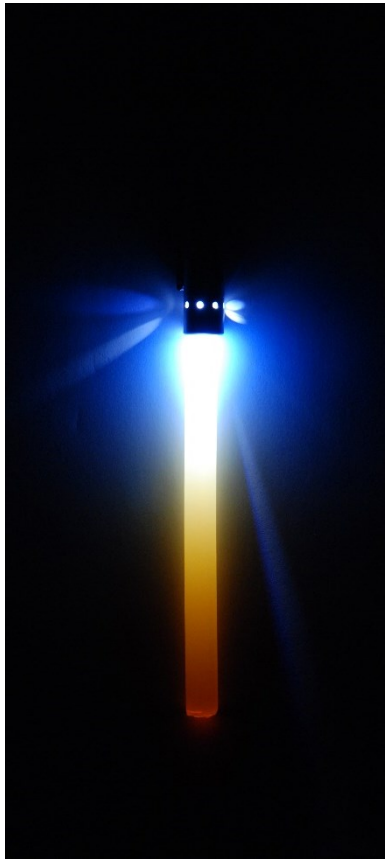
- Yellow reflects only in the red spectral range,
- Red reflects in the red spectral range,
- Blue does not reflect,
- Green does not reflect.

Outside: Between UV and IR



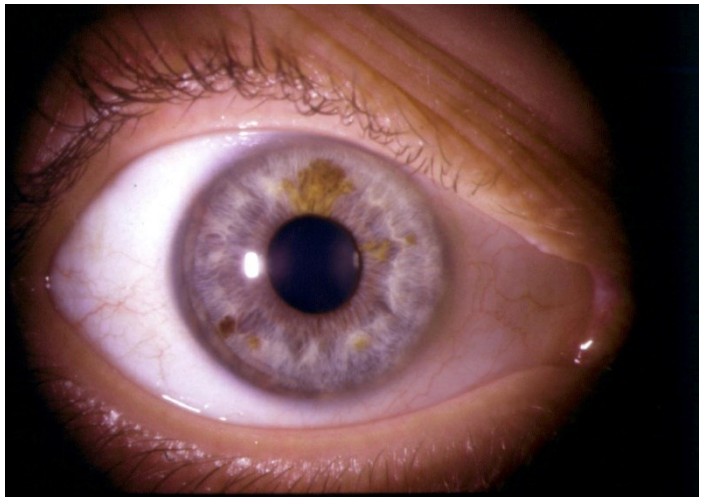
- The light visible to us begins at about 400 nm with blue-violet. Via blue, green, yellow and orange, the visible range extends to red at about 700 nm.
- At the short-wave end the ultraviolet and at the long-wave end the infrared range follows.Some animals can also see in the UV or IR range.
- We do not know what they see or which colors they perceive: we are trapped in our spectral range and our colors

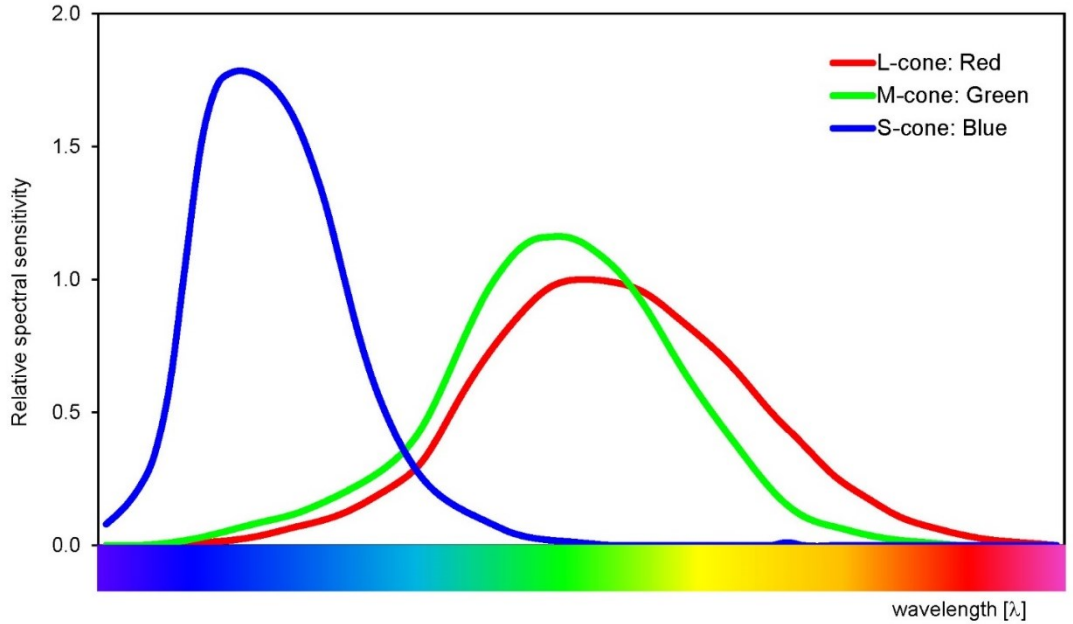
Outside: The sun shines on us



- The sun is our light and life giver
- The light rays need about 8 min to reach the earth
- Due to light scattering, we perceive it as blue when the sun is almost vertical at noon.
- Towards evening, the light rays need a longer way through the atmosphere, which is why more red rays are scattered.
- The picture shows a simulation of these phenomena (cloudy glue stick with LED lamp).

Inside: Our eye receives light





- When light hits the retina of our eye, it triggers an optical stimulus there
- The retina has three cones, each of which is sensitive to one spectral range
- They always react together to incident light and not individually
- The green and the red cones are responsible for our yellow perception.
- Since the green and red cones are close together, we cannot perceive dark yellow.

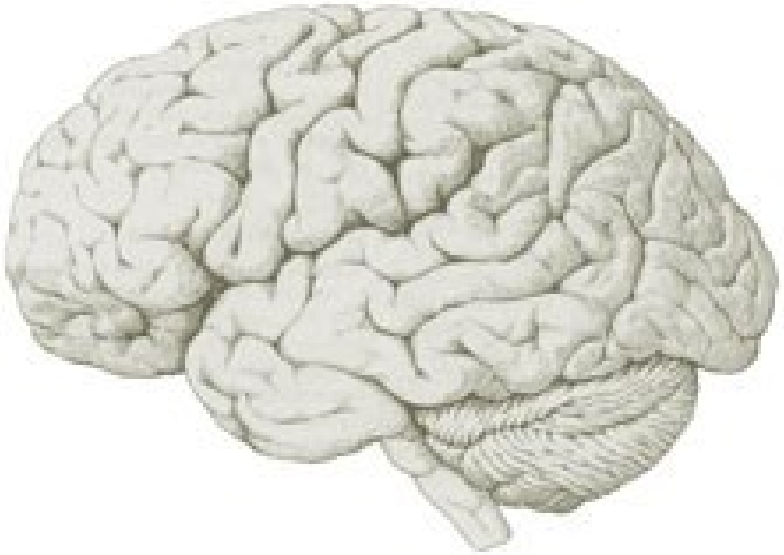
Inside: The same car, different colors?

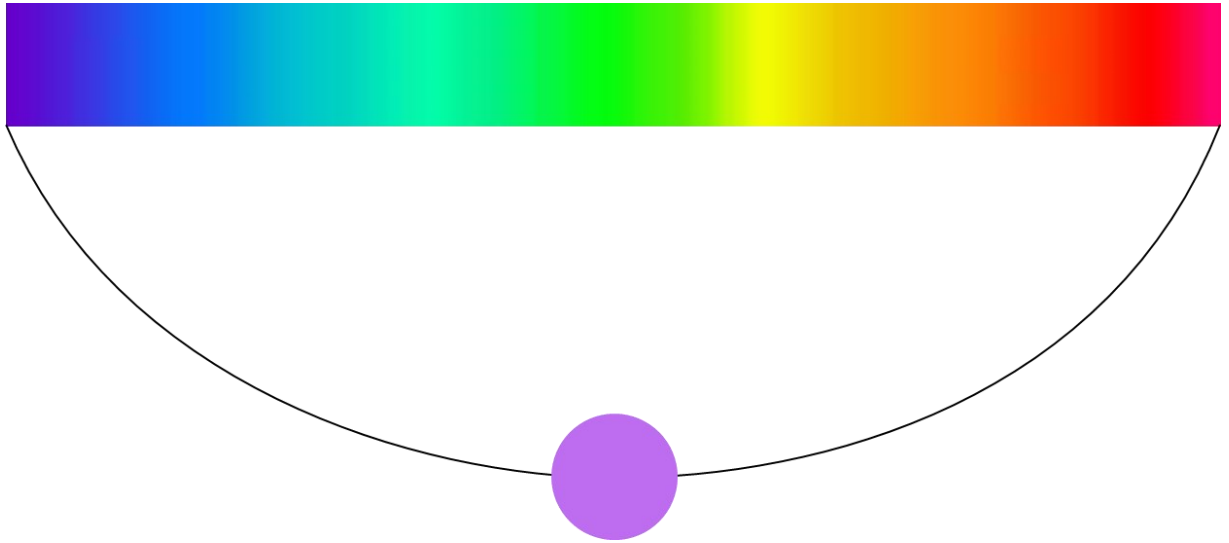
- Some people have a more or less severe defect of the cones.
- Especially the red-green vision is affected
- This color deficiency occurs mainly in men (is dominantly inherited to men)
- In the original picture you can clearly see the green door in the red car
- In the right picture the color vision defect is simulated; it shows no difference between the door and the car body

Inside: Color dificency – missing red and green

- On the right the original image, on the left the simulated image.
- Clearly recognizable is the absence of green in the leaves, which appear yellow in the simulated image
- Also noticeable is the absence of red in the upper right area of the simulated image, where instead of purple only blue is visible

Inside: Our brain reacts

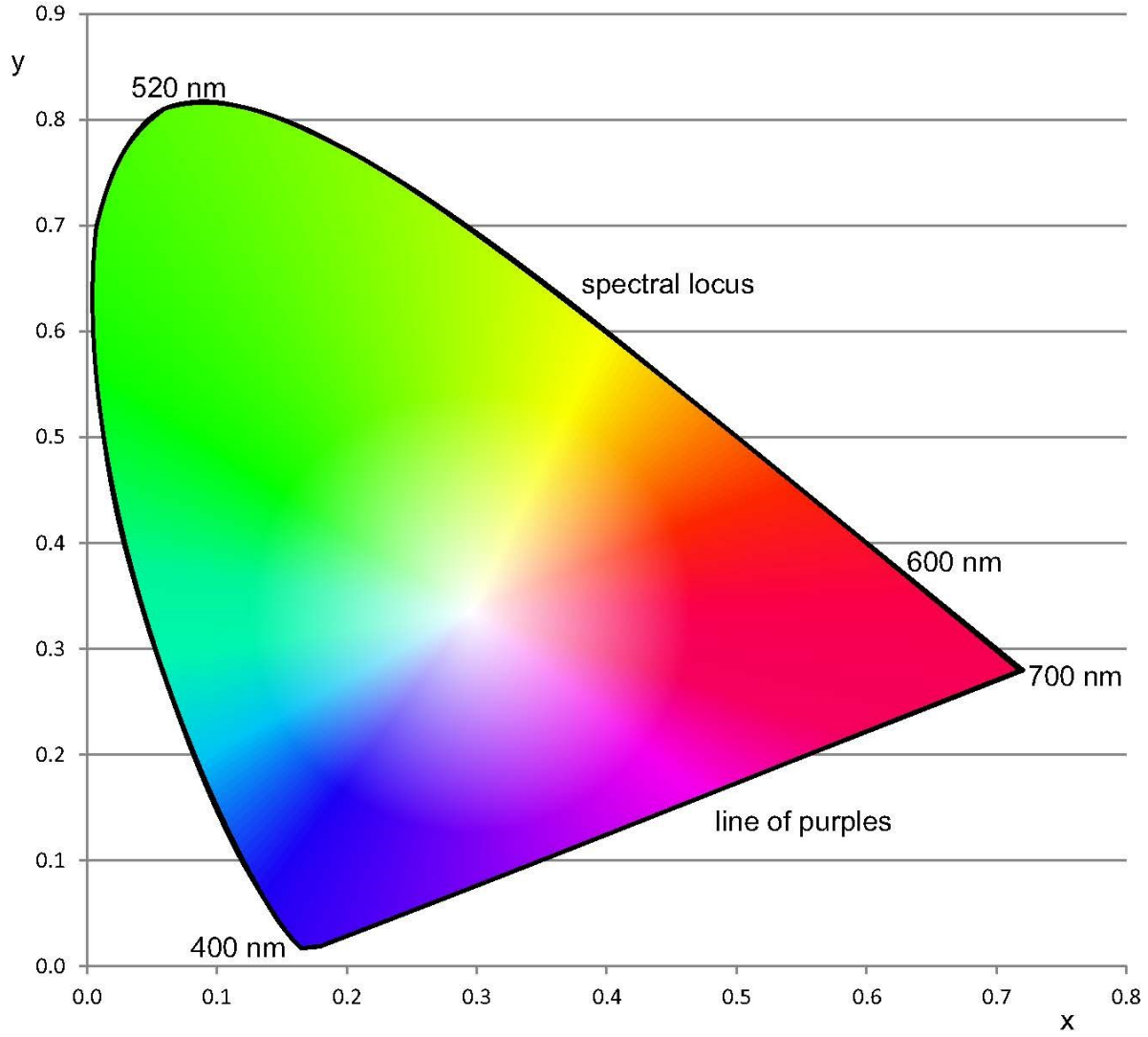




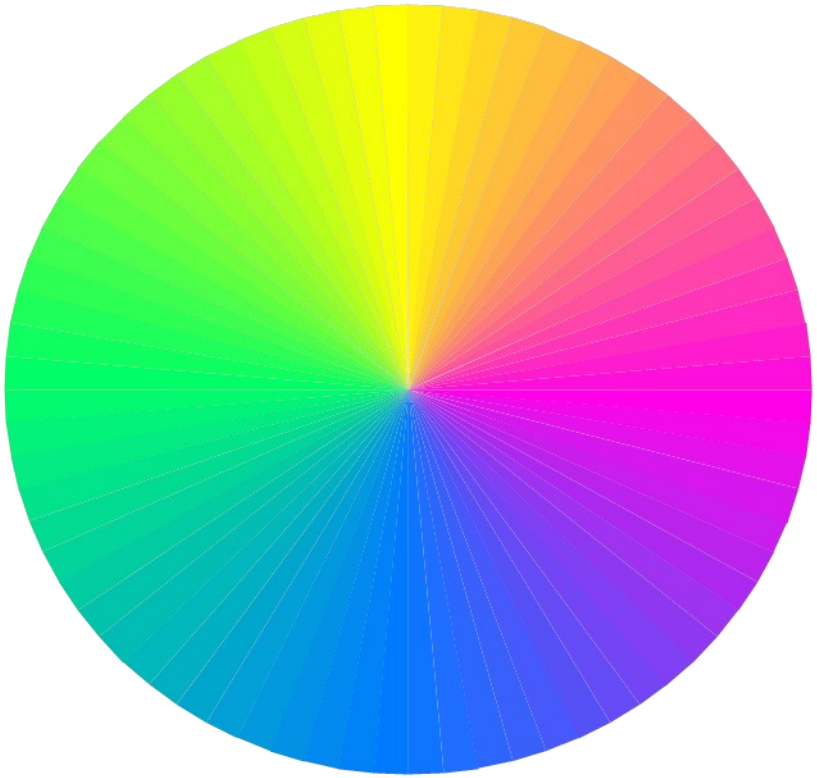
- The optical nerve transports the signals from the eye to the brain
- In the brain they are translated into colors
- The greatest achievement of our brain is the combination of the two end colors red and blue of the spectrum to a new color.
- This purple does not exist in the color spectrum
- Purple exists like all colors only in our brain!
- Outside of our brain and before our eyes there are no colors!

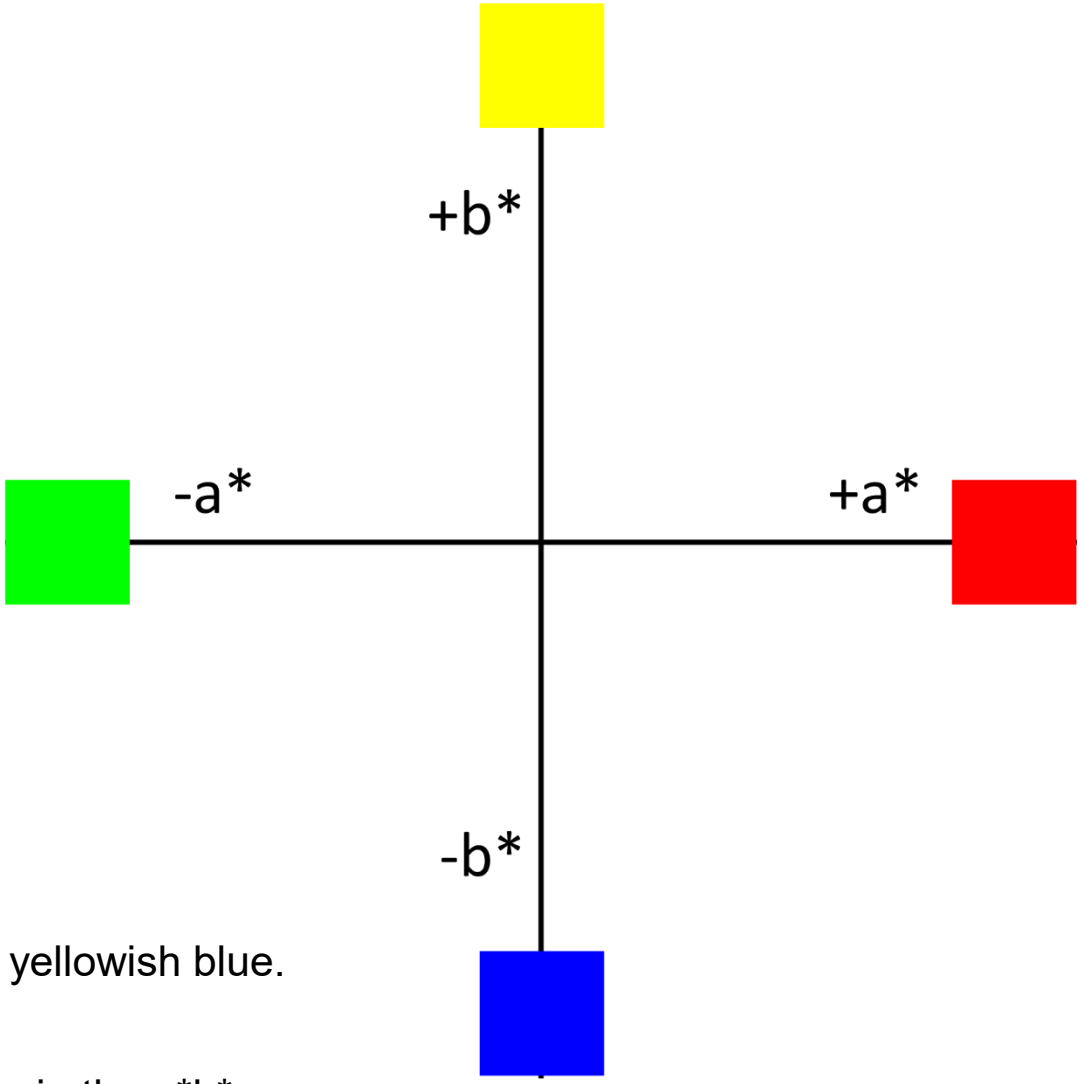
Inside: Connecting red and blue gives the circle

- The ability of our brain to link the two end colors of the spectrum is also shown in the chromaticity diagram
- The purple line in the chromaticity diagram represents all the purple colors that do not occur in the spectrum



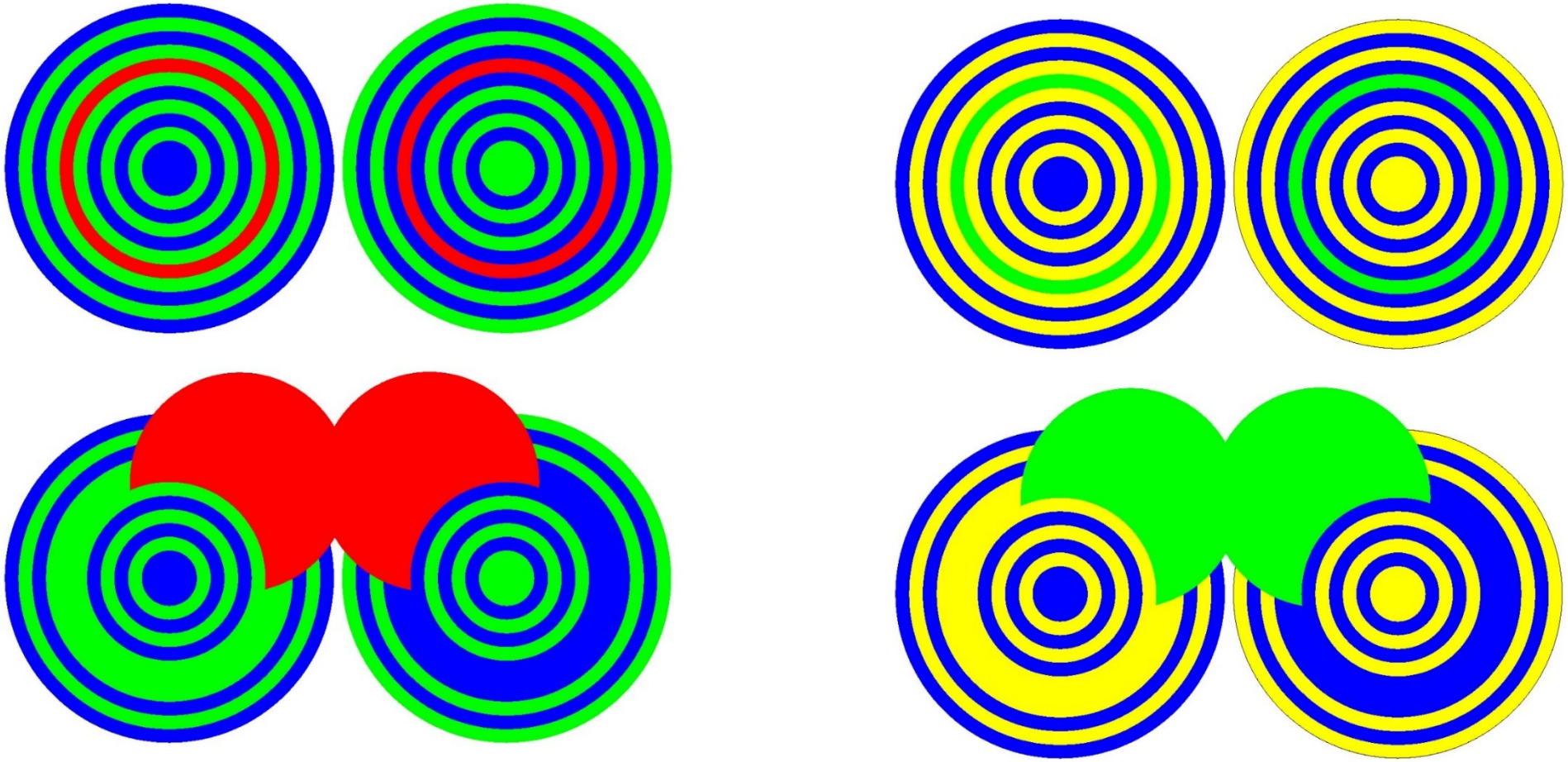
Inside: Our perception knows no blueish yellow





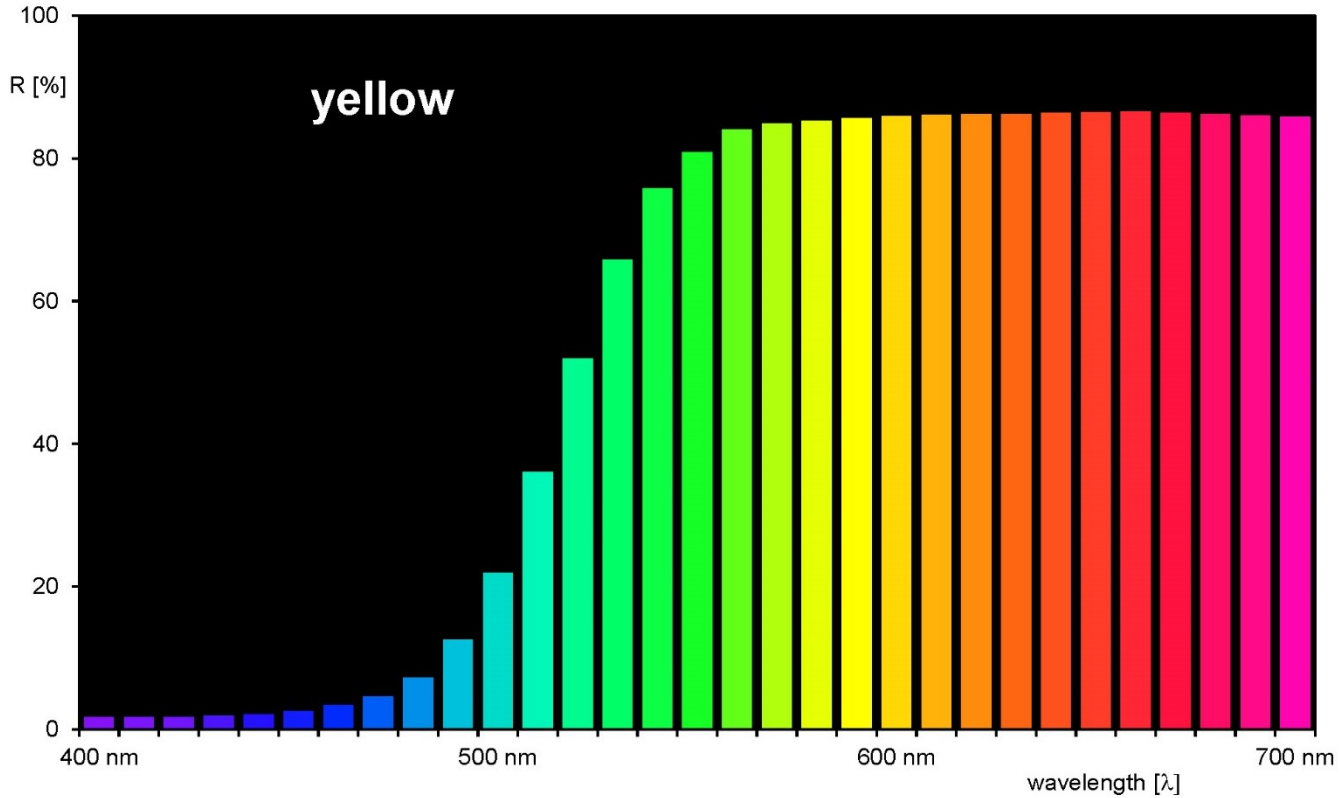
- The brain links the end colors of the spectrum
- This creates the color wheel
- Our color perception does not know a bluish yellow or a yellowish blue.
- It also does not know greenish red or reddish green
- Therefore, colors are arranged in a coordinate system as in the a*b* diagram.

Inside: Our brain fools us



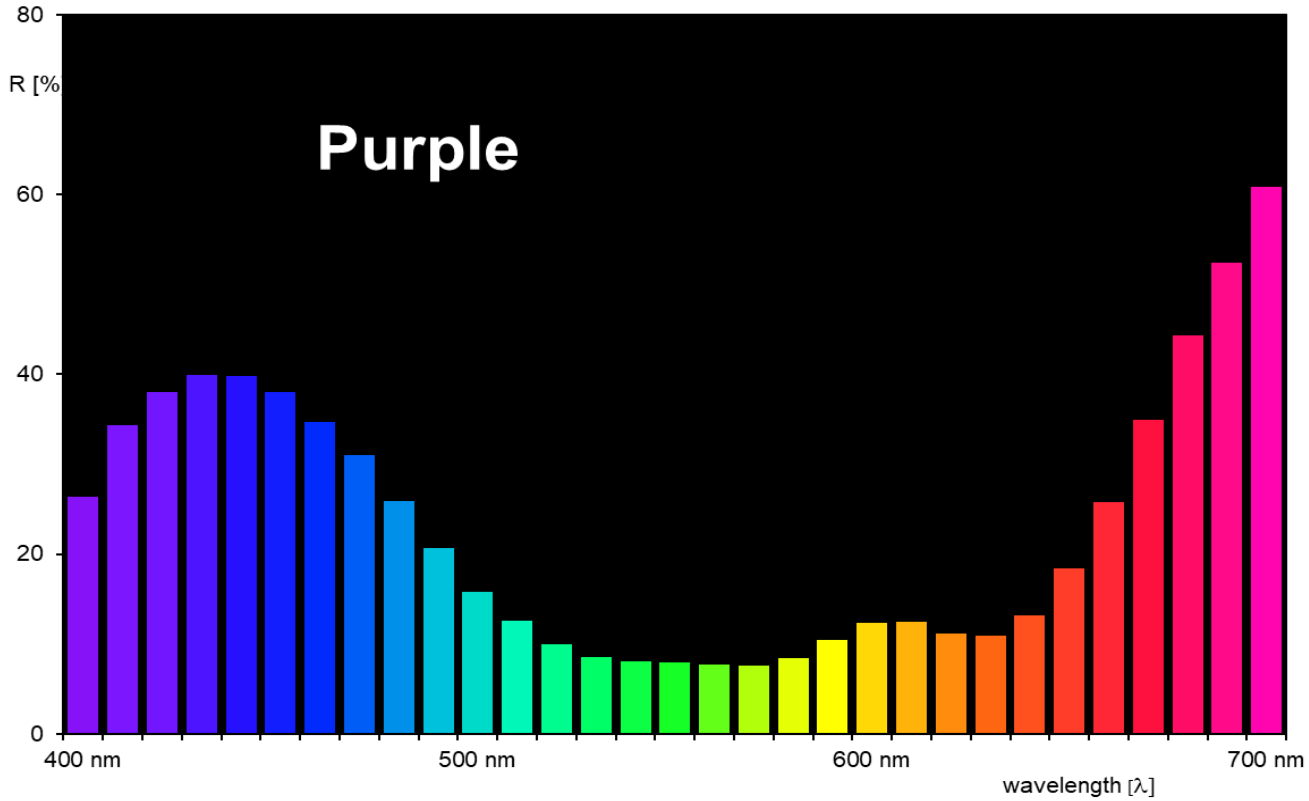
- Our brain is easily fooled
- Colors in the environment influence our perception
- When assessing colors, a neutral-colored environment is important (light booth)

Outside & inside: Yellow reflects over a big range



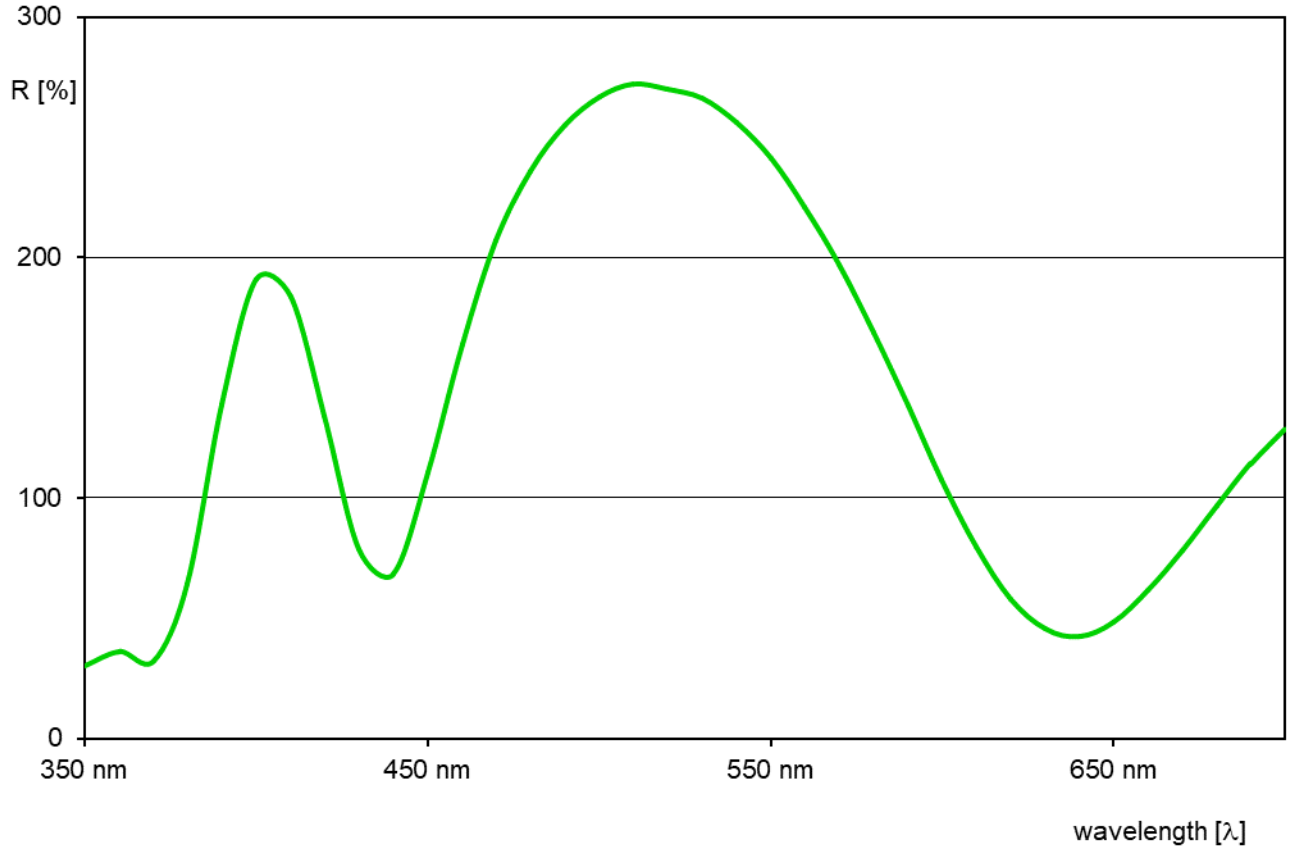
- With a yellow object we cannot recognize that also strongly reflects in the green and red spectral range
- The brain puts both areas together additively to yellow
- Reflects basically always in the entire spectral range

Outside & Inside: Purple has no own spectral area



- The reflection curve of purple - here a purple pigment - clearly shows the reflections in the blue and red range
- Our brain cannot show these reflections separately, it shows the mixture of both to purple
- Purple has no spectral range of its own

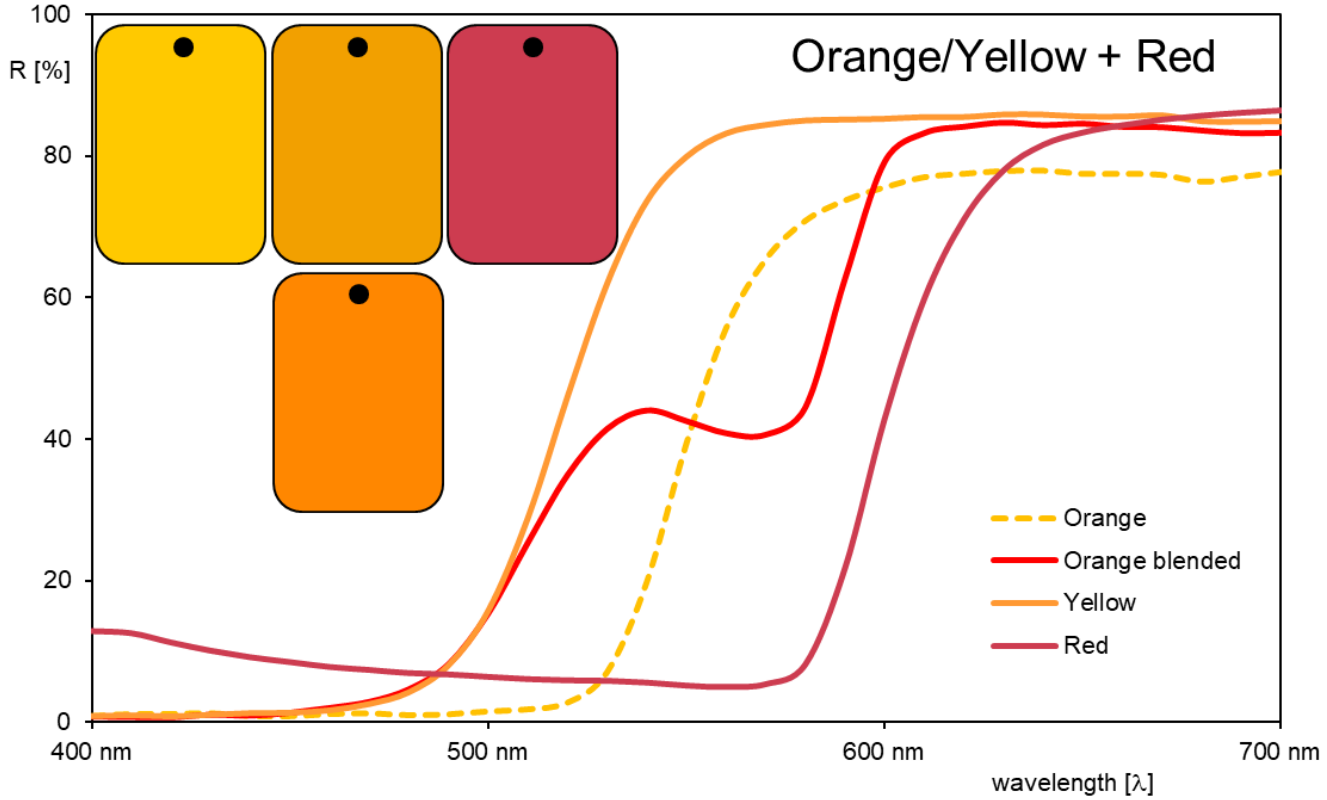
Outside & Inside: More than one peak



Several maxima, one color:

- Outside: The instrument “sees” the maxima
- Inside: Our eye and brain “smooth out” the reflections

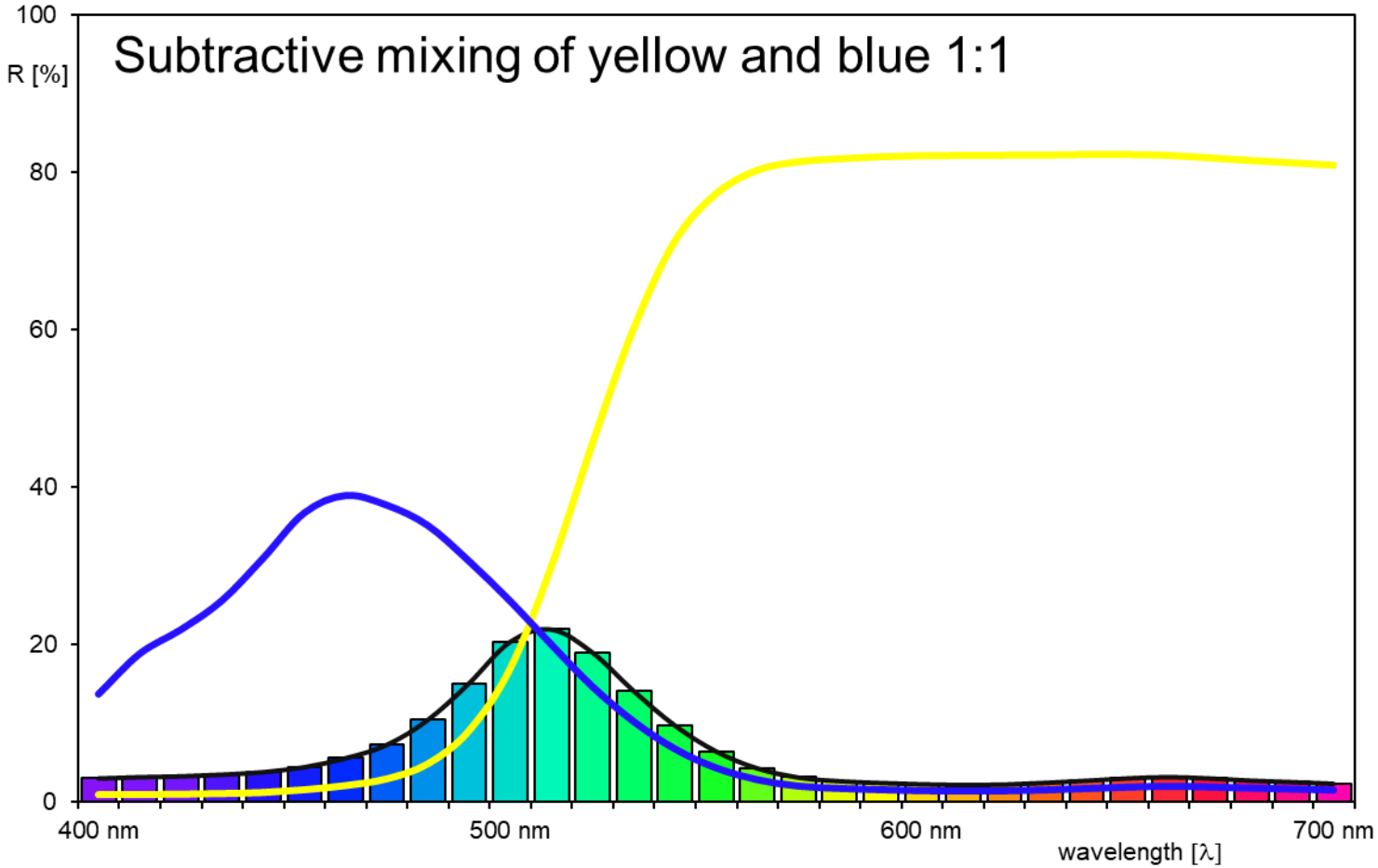
Outside & Inside: We can‘t differentiate



- Only the reflection curve shows that a mixed orange has a saddle shape of the reflection curve
- An original orange does not have this saddle
- The conversion to a*b* color values would not show this either

Outside & Inside: Green is left!

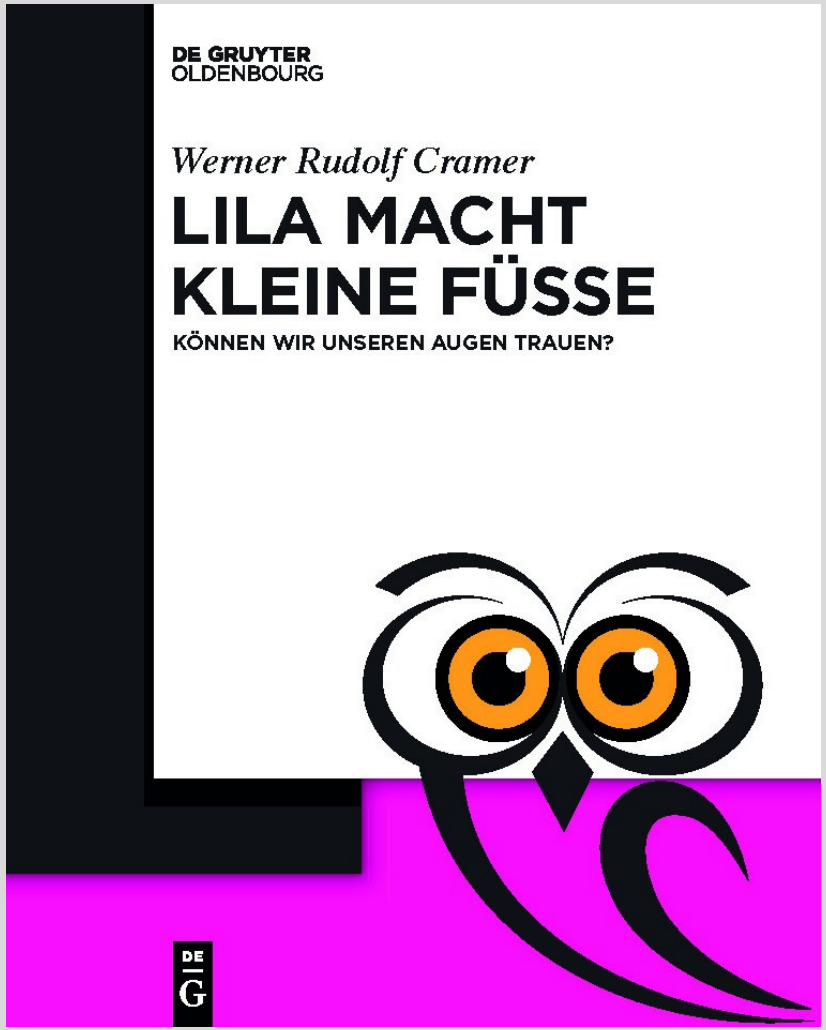
- Yellow + Blue = Green
- Green remains "left over" when mixing
- Green is not a mixed color, as is often claimed by artists



Short conclusion

- Outside our eyes exist only light rays
- Colors are created in the brain by translating the light rays into color
- The brain combines the end colors of the visible spectrum into purple
- This color does not exist in the color spectrum
- A measuring instrument lets us understand the processes in front of our eye

Thank you very much for your attention!



- More information in my new book
- Have a look here: www.lila.wrcramer.de
- An english version will also be published