DEFECTS IN COLOUR VISION

- *Follow instructions in this worksheet, if you have difficulty understanding them, ask us.*
- *Write down both your partial and final results into the text and prepared graphs.*
- *If you want, you can record videos and take photos of conducted experiments, etc.*

The goal and idea of the experiment

You will explore the defects in colour vision.

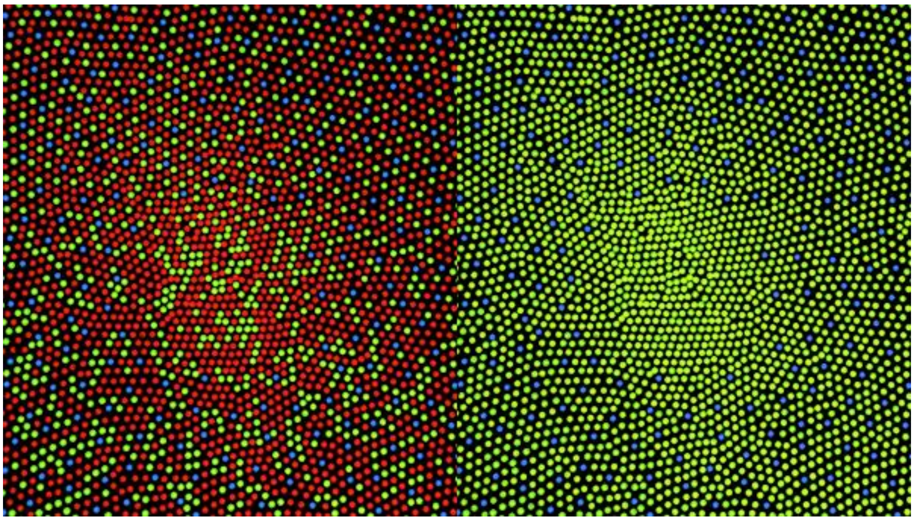
Colour vision of the human eye

We have two types of photoreceptor (on light reacting) cells on retina – the cones and the rods.

We recognize 3 kinds of cones– L-cones most sensitive on yellowish green light ( ), M-cones most sensitive on green light ( ) and S-cones most sensitive on purple-blue light ( ).

We recognize two types of cone defects. One of them is **-anomaly** which causes one of the cones to be most sensitive on a different colour than it should be and thus the brain can't differentiate some colours. The second defect is **-anopia** which causes one of the cones to be absent (see picture 1).

Since we have three types of cones, the defects described in the paragraph above can affect either one; **prot-** (for L-cone), **deuter-** (for M-cone) and **trit-** (for S-cone). We can thus talk for example about protanopia, which is the L-cone missing, or tritanomaly, which is the S-cone being most sensitive to a different colour. The most extreme case is achromatopsia, which causes two cones to be absent and colours cannot be distinguished at all.



Picture 1: The distribution of cones on retina around fovea of a healthy human (left) and a person with protanopia (right) L-cones are coloured red, M-cones are green and S-cones are coloured blue. Note that the fovea is missing S-cones in both cases. This picture is purely illustrative and the colours and numbers of cones don't correspond to reality.

Task 1: Cone saturation

1. Put on glasses with red and teal filters instead of lenses. Note down which filter is on which eye:

   Left eye:

   Right eye:

2. Read the cursive text bellow that describes the point of this experiment with the glasses on.

To prevent overstimulating the brain with a never-ending flow of information, it starts to ignore unchanging stimuli after a while. We can commonly notice this effect in hearing (for example we don't perceive loud music to be loud after listening to it after a while), smell (for example we stop smelling our own perfume after a while) and sight.

While you were reading the text, the eye with red filter on received mostly only red light, which saturated mainly the L-cone. The other eye got mostly the M-cone and S-cone saturated.

3. After reading this step, take off the glasses and alternate looking with one eye and the other eye at a nearby wall. Describe the hue of the wall.

   Hue of the wall when looking with the left eye:

   Hue of the wall when looking with the right eye:

Looking with the eye with red filter changed the hue of the wall to teal because the brain started to ignore the signal from the L-cone that reacts the most on red light. After taking off the glasses, the brain started receiving signals from all cones, but the signal from the L-cone was still ignored and thus the signal from the S-cone and M-cone were "stronger", which resulted in the teal hue. The other eye had analogous effect.

Task 2: Exploring deuteranopia

1. Look at picture 2 bellow which shows how the colour spectrum is perceived by a healthy human and a person with deuteranopia. Try to describe the main differences between the spectra.

Picture 2: Colour spectrum perceived by a healthy human (up) and deuteranope (down)

Light seen by the eye causes excitation of the cones. The intensity of the excitation depends on the colour of the light. Turn on applet ConeSpectralSensitivity.ggb which simulates this.

2. Determine how much each cone is excited by differently colour lights based on the applet. Write these values down into the table bellow.

Colour	Red			Yellow			Green			Teal			Blue		
Cone	L	M	S	L	M	S	L	M	S	L	M	S	L	M	S
Healthy person															
Deuteranope															

3. A healthy human is capable of differentiating colours because they excite different cones with different intensity. Using the table above, explain why red, yellow and green colour are indistinguishable by deuteranopes.

Task 3: Simulating deuteranomaly

1. The applet *Color Blind Pal* is running on the tablet. This applet simulates deuteranomaly through camera. Look at your surroundings through the applet (walk around the lab, look outside the window, etc.).

2. Describe how the colours changed.

Colour-blindness is usually corrected using special glasses that block out certain shades of colours and help the brain of a colour-blind person distinguish colours that they had problems with before. Our glasses are used for people with protanomaly and deuteranomaly.

3. Take on these special glasses and look around. Describe how the colours changed.

The glasses block our certain shades of colours and help distinguish colours that are close to each other on the colour spectrum.

4. What shades of colours are blocked by our glasses? (Hint: What colours are poorly distinguishable by a person with deuteranomaly?)

Conclusion

Colourblind people usually can't see certain/any colours. Deuteranomaly is the most common type of colour-blindness. People with deuteranomaly can't distinguish