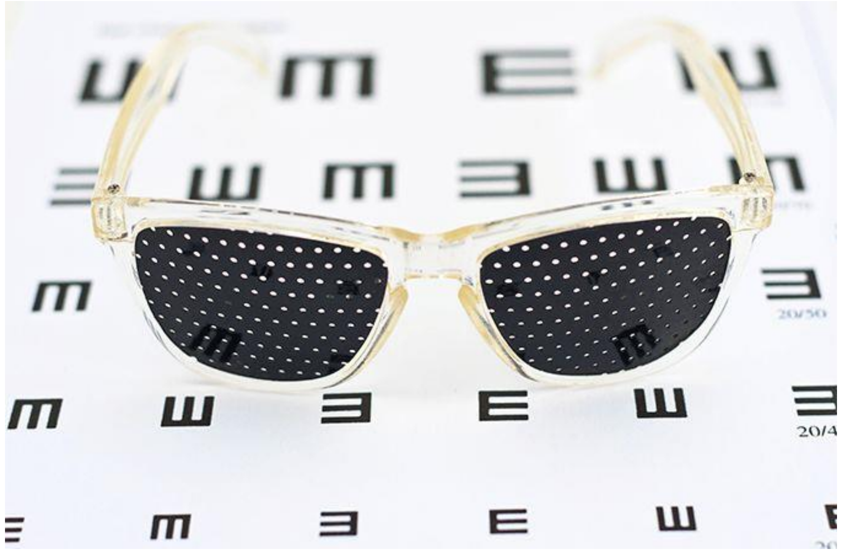
8. Seeing through pinholes

An opaque sheet with regularly arranged pinholes corrects myopia similar to corrective lenses. Explain this effect and introduce parameters to describe image perception by myopic humans with and without pinhole glasses.

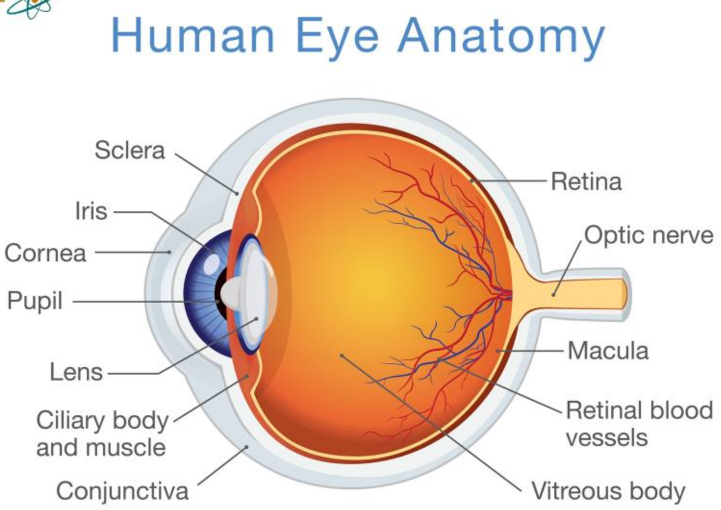
Rep: *Nikoloz Burduli*

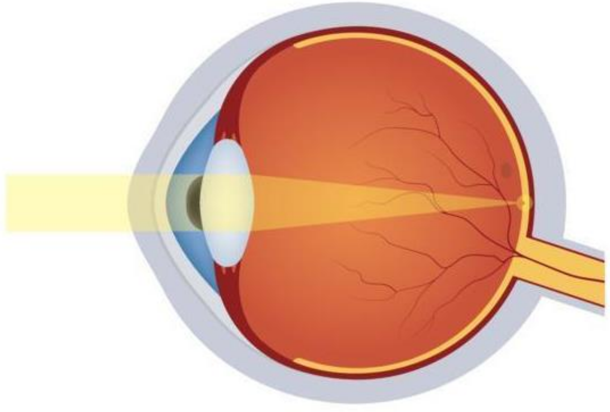
Presentation Plan

- The working principle of the eye;
- Explanation of the phenomenon;
- Theoretical calculation;
- Experiments;
- Comparison of the theoretical and experimental results;
- Conclusion.

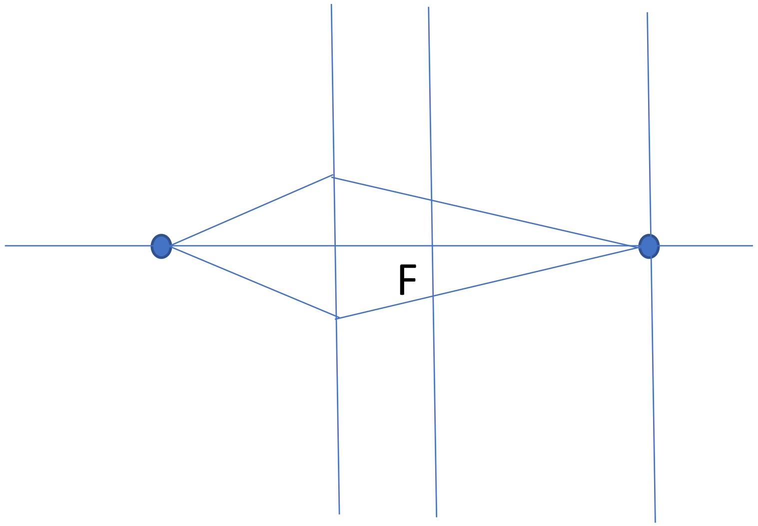


The working principle of the eye



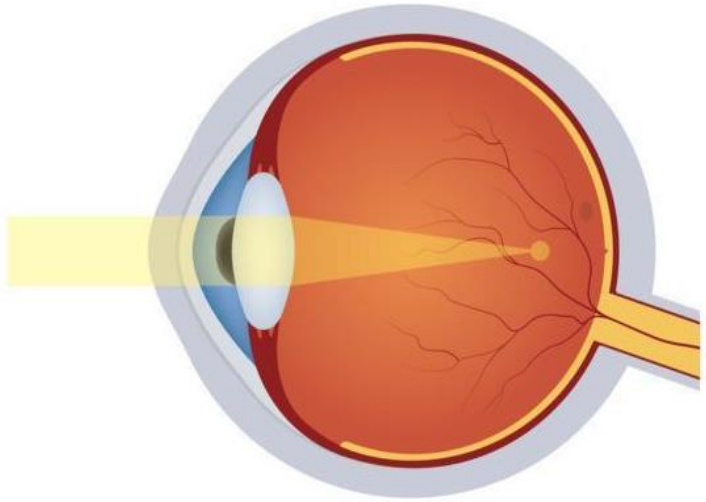


Normal Vision

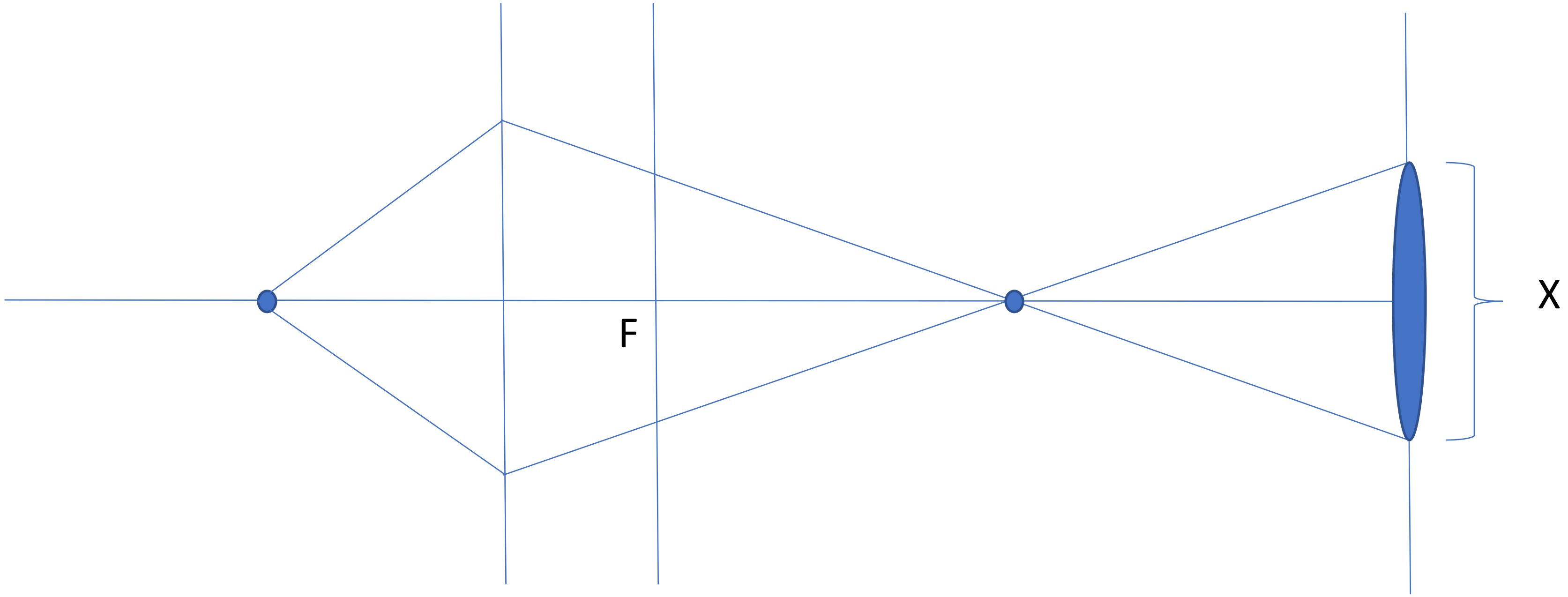


Phenomenon | Theoretical Model | Experiment | Conclusion

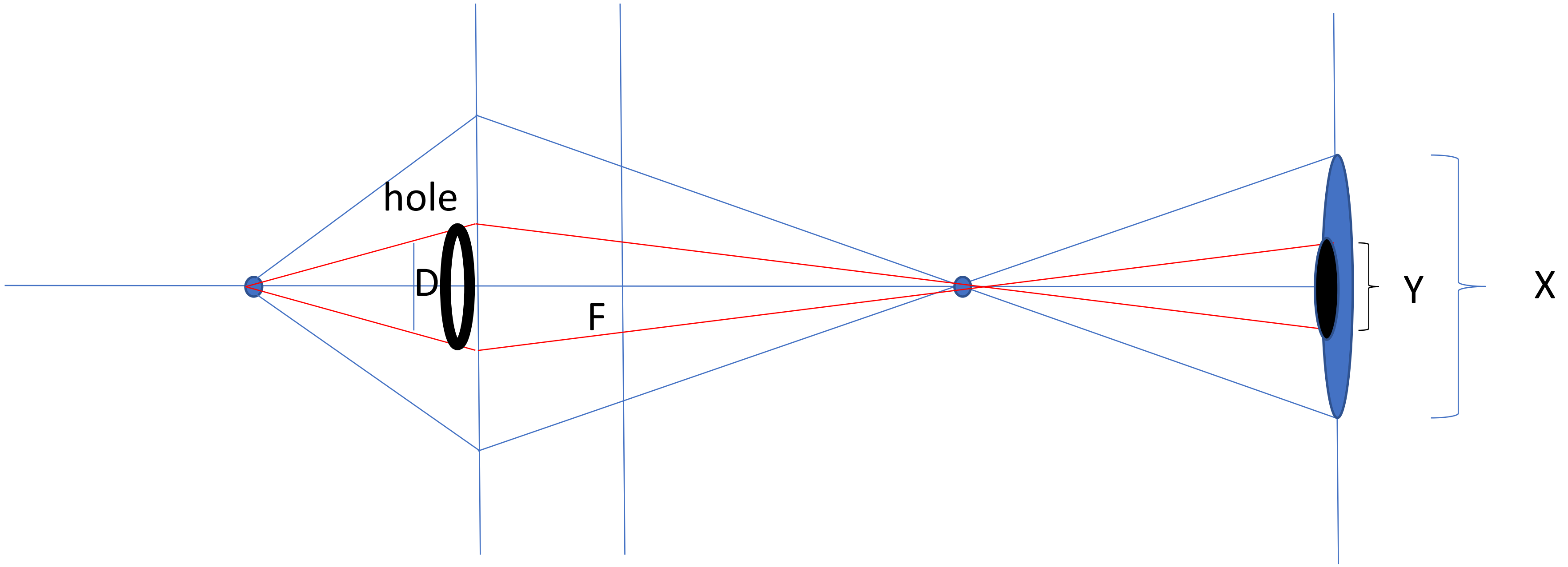
Myopic Vision



Myopic



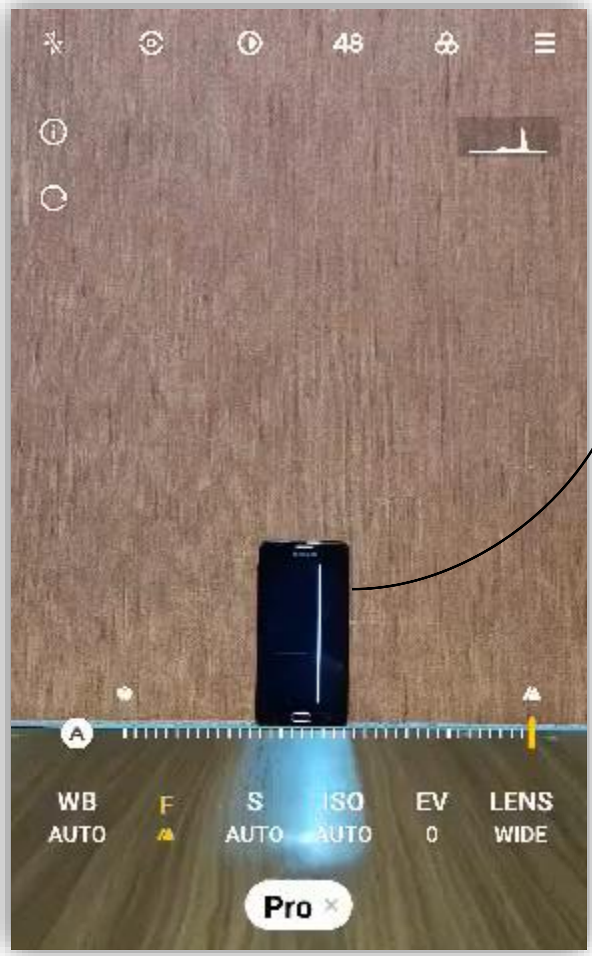
Explanation of the phenomenon



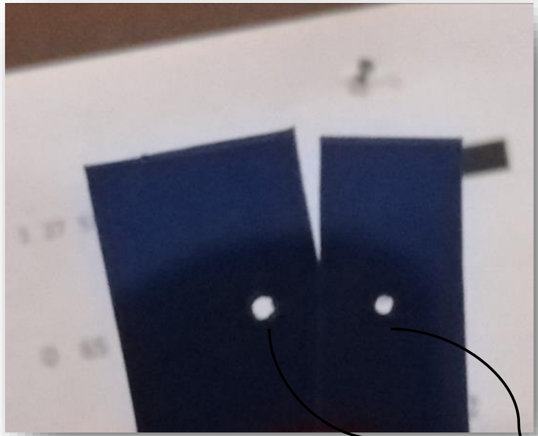
Vision through the pinhole

Experimental setup

Experimental setup



Phone with a white line;

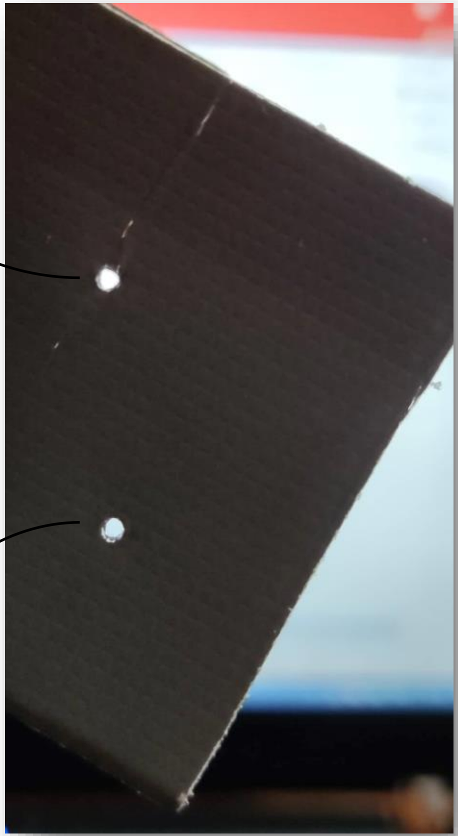


1.5 mm

2.5 mm

3 mm

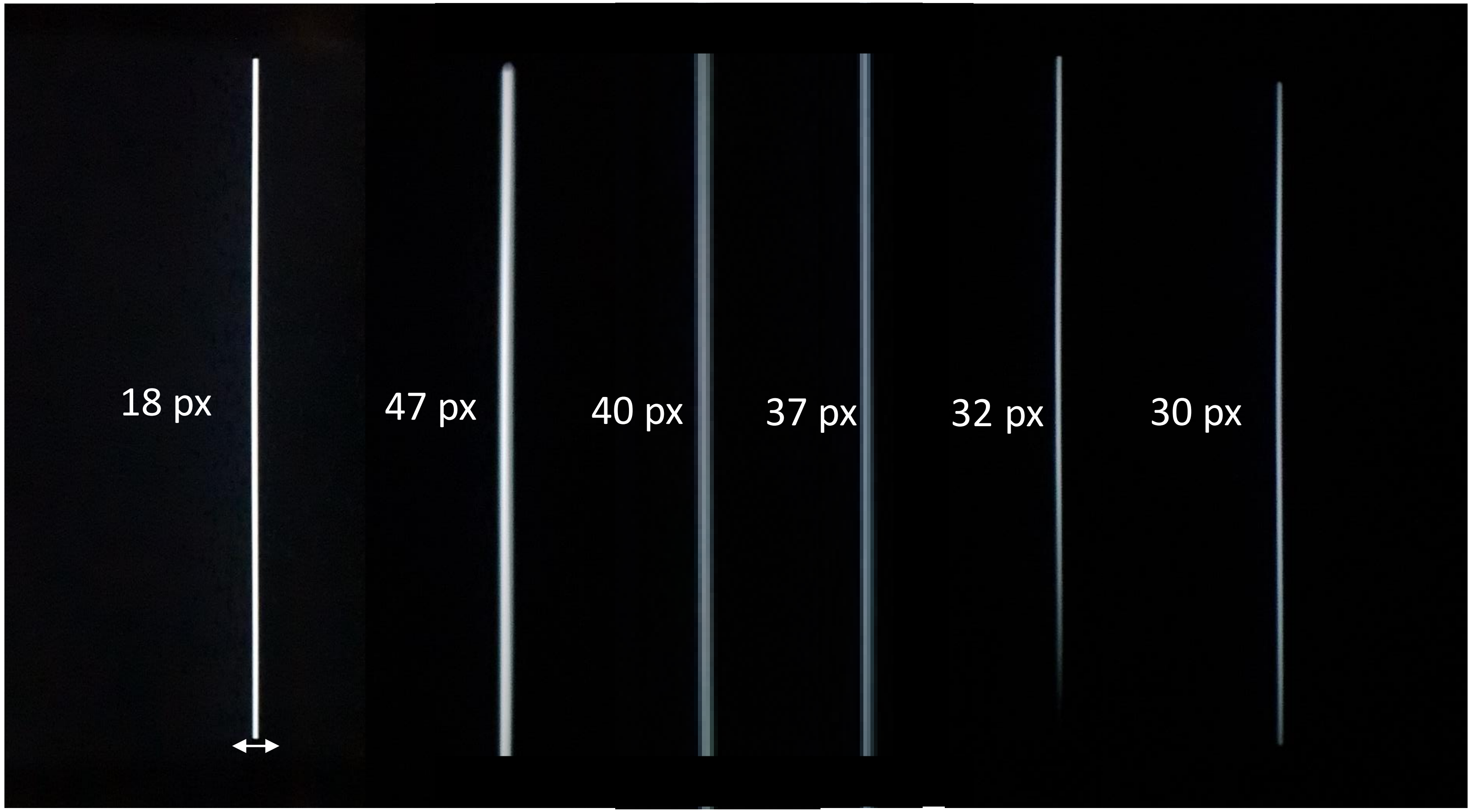
2 mm



Caliper

Experiments with camera

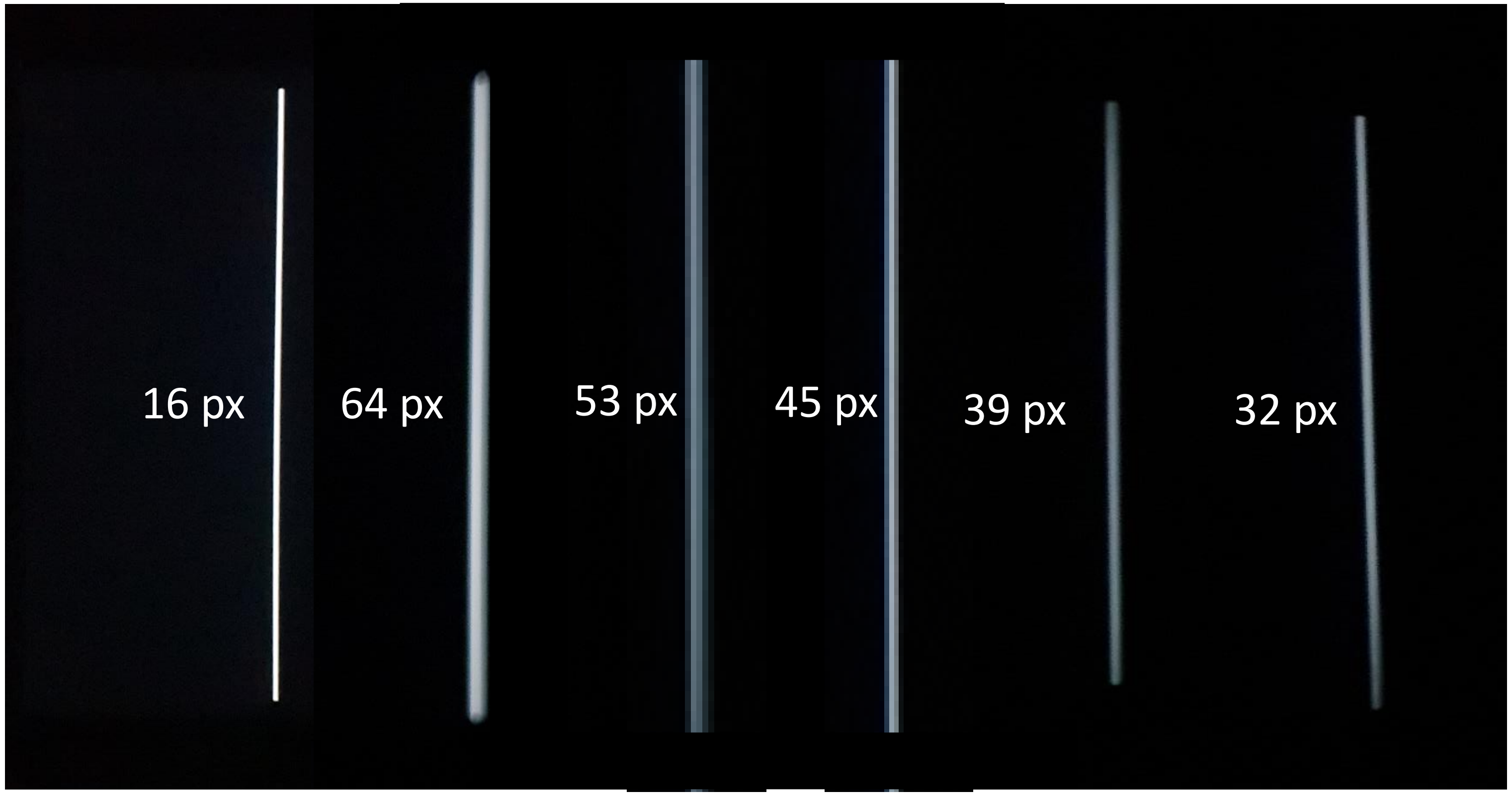
The distance between the camera and the object is 15 cm;



Focused on the object | Myopic vision | 3 mm | 2.5 mm | 2 mm | 1.5 mm

Experiments with camera

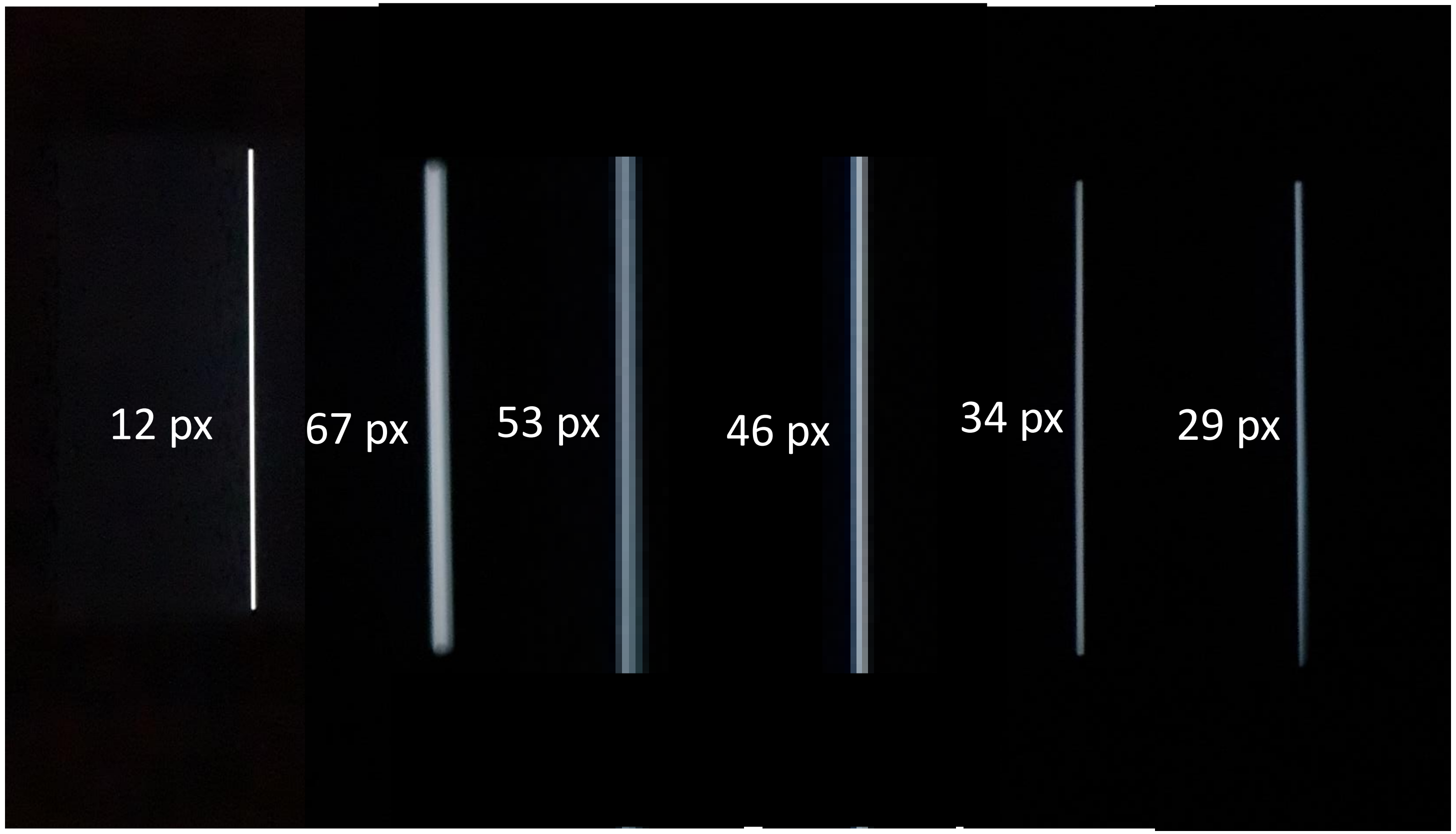
The distance between the camera and the object is 20 cm;



Focused on the object | Myopic vision | 3 mm | 2.5 mm | 2 mm | 1.5 mm

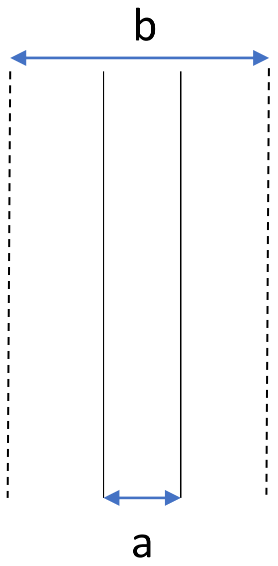
Experiments with camera

The distance between the camera and the object is 25 cm;



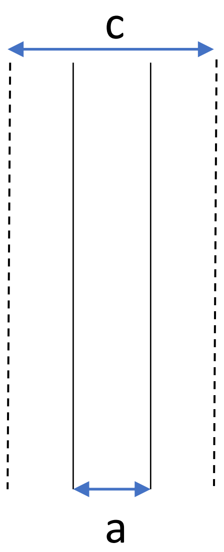
Focused on the object | Myopic vision | 3 mm | 2.5 mm | 2 mm | 1.5 mm

Parameter to describe myopic vision for camera



a – real size of the object;
b – the size of the blurred object;
b – a = blur size;

a – real size of the object;
c – the size of the blurred object (with hole);
c – a = blur size for hole;



Parameter for blurring:

$$\boxed{\begin{aligned} \eta_0 &= b - a \\ \eta_1 &= c - a \end{aligned}}$$

Experiments with human eye

1 27 57 72 46 98 23 81

0 65 29 44 31 97 3 98

52 23 11 76 87 90 1 12

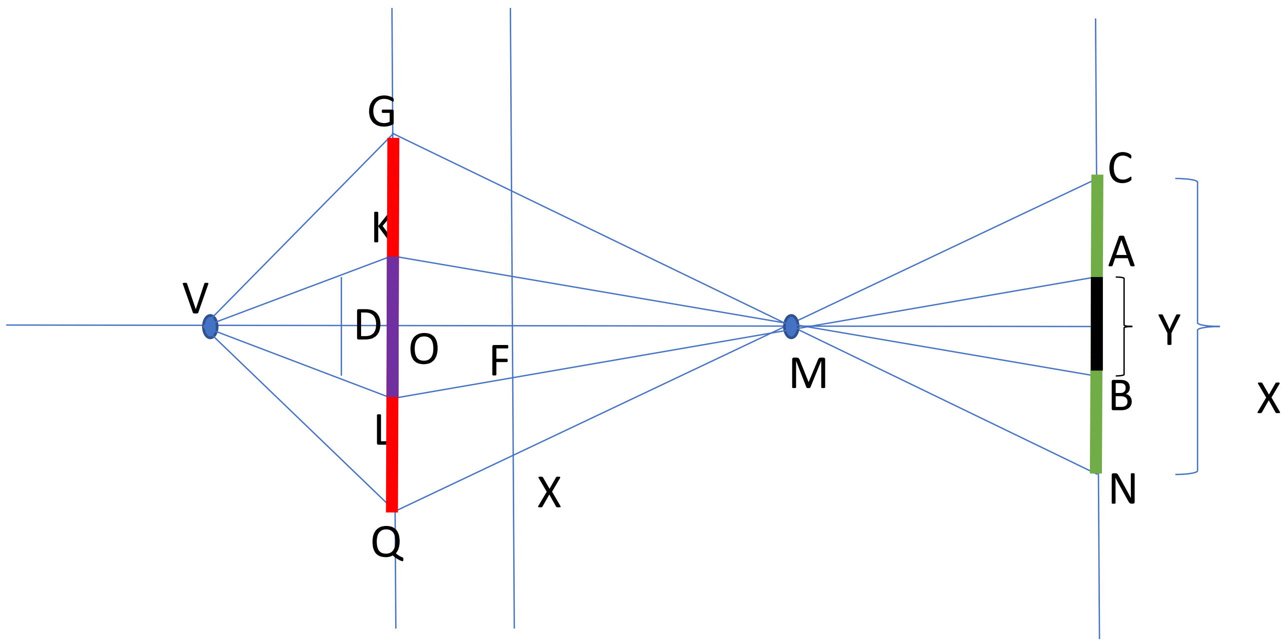
74 82 16 28 99 12 29 77

57 74 16 34 5 10 80

- decreased distance between inscription and human till they could read it
- measured critical distance

Theoretical calculation

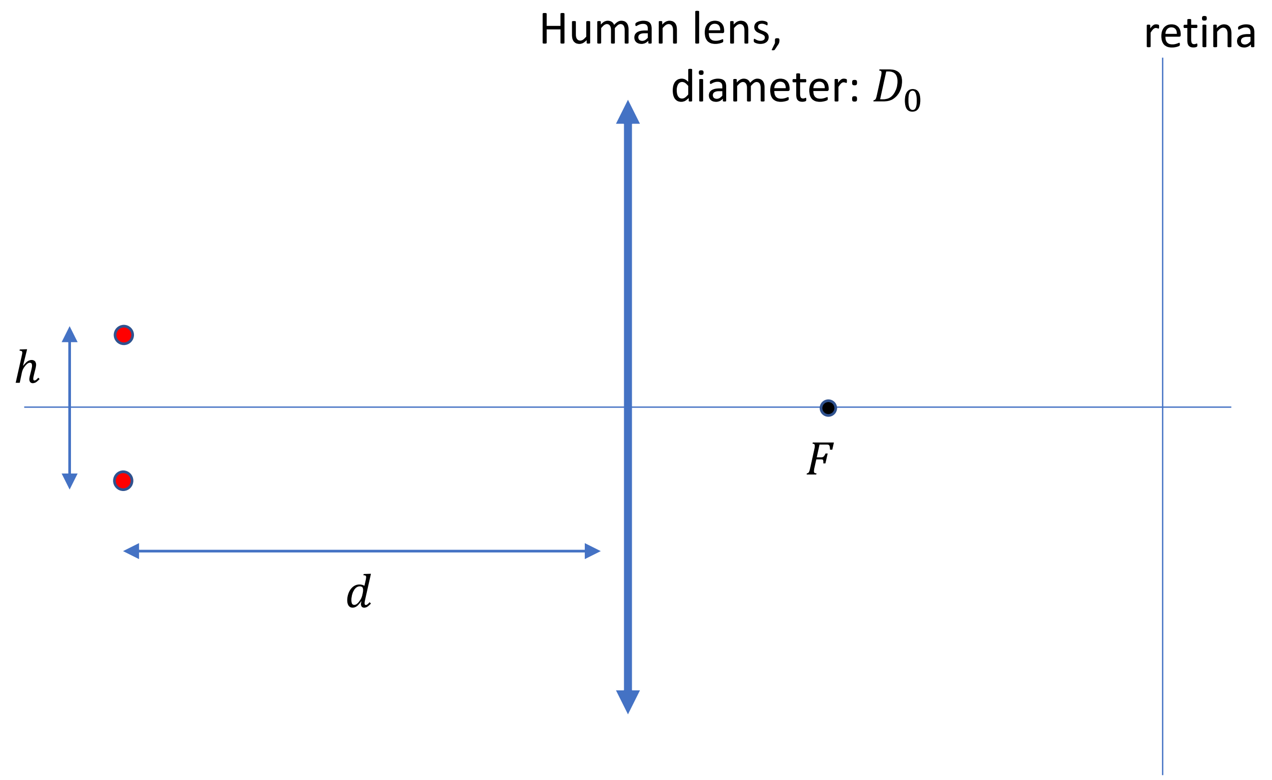
D − *diameter of the hole*;
X −*image obtained without a hole*;
Y − *image obtained with a hole*;
GQ − *diameter of the lens* $= D_0$;
$KL \approx D$



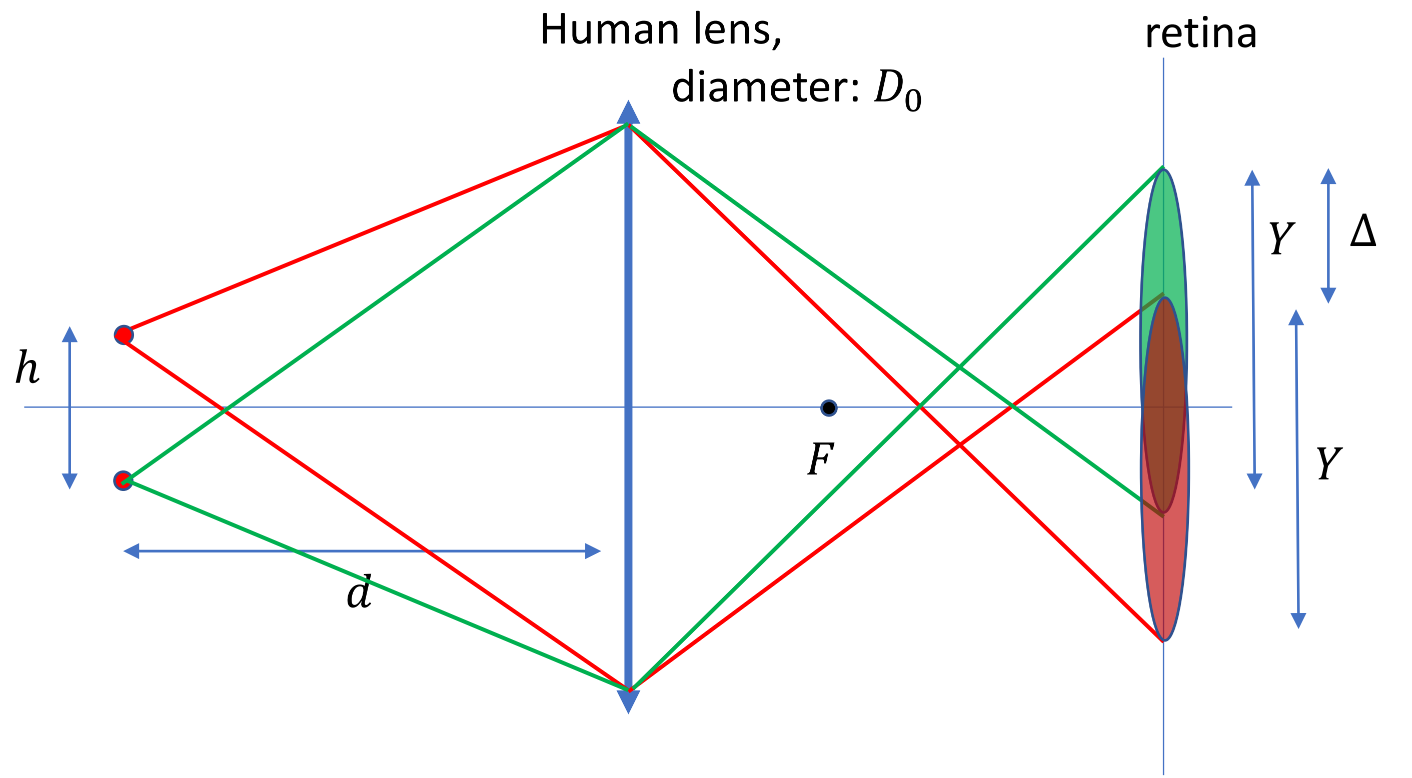
$$\left.\begin{array}{l}\Delta\mathrm{AMB} \sim \Delta KML \\ \Delta\mathrm{CMN} \sim \Delta GQ\end{array}\right\} \gg \left.\begin{array}{l}\dfrac{CN}{AB} = \dfrac{GQ}{KL} \\ KL \approx D\end{array}\right\} \gg \boxed{\dfrac{X}{Y} = \dfrac{D_0}{D}} = \dfrac{\eta_0}{\eta_1}$$

Phenomenon | Theoretical Model | Experiment | Conclusion

Theoretical model for human eye

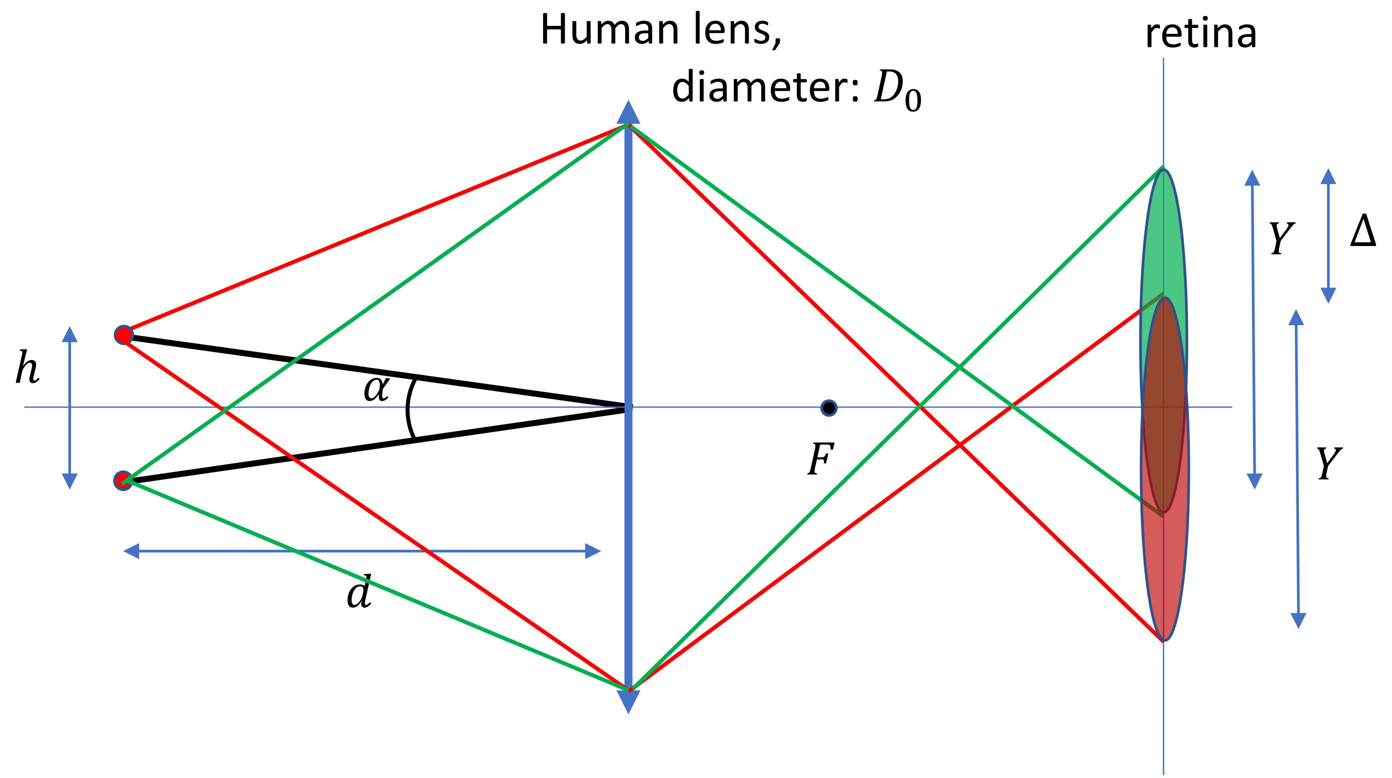


Theoretical model for human eye



$$\boxed{\Delta = Y}$$

Theoretical model for human eye



$\Delta_{cr} = Y$

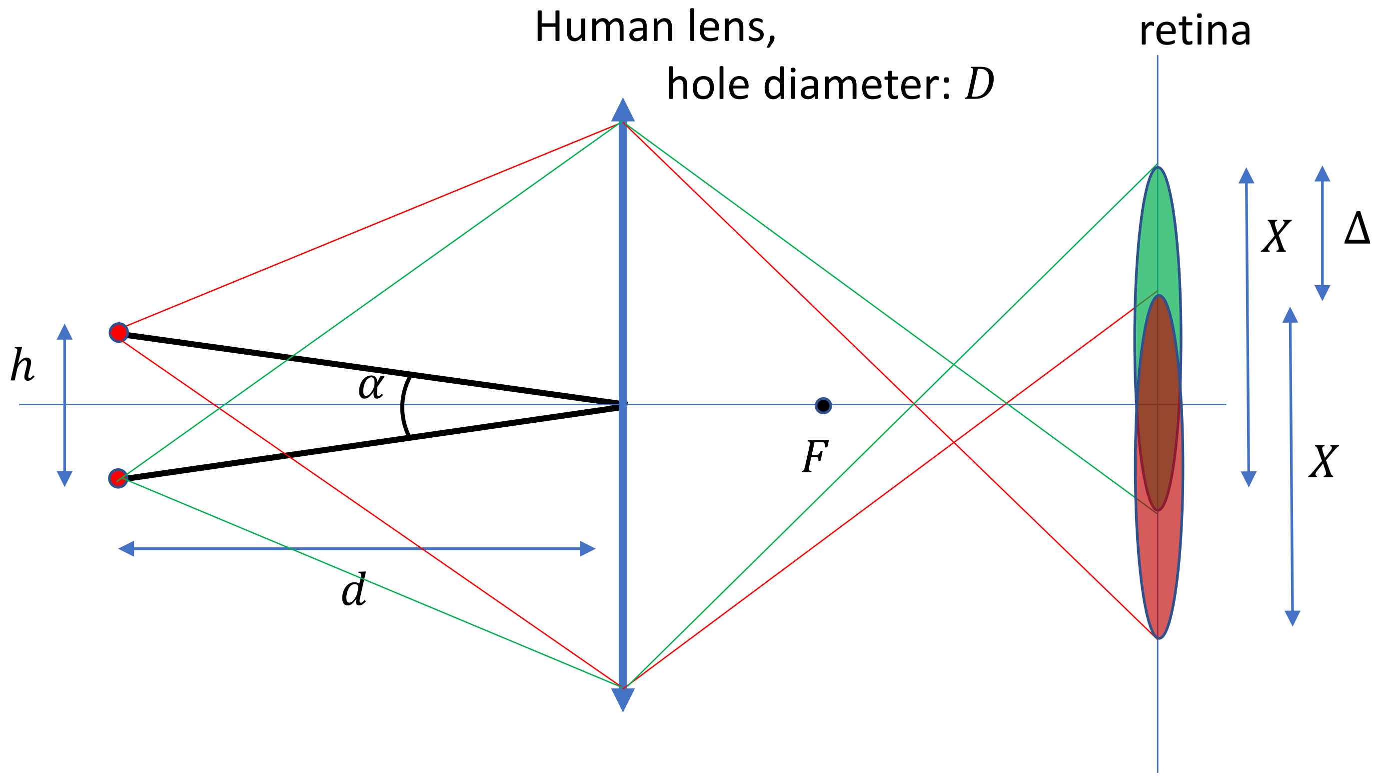
$$\boxed{\alpha - angular\ resolution}$$

$$\Delta = f(\alpha) \approx k\alpha \qquad \alpha \ll 1$$

$$\boxed{\alpha_{cr} = \frac{Y}{k}} \equiv \alpha_0$$

Theoretical model for human eye

Using the hole:



$$\frac{X}{Y} = \frac{D_0}{D}$$

$$X = k\alpha$$

$$Y = k\alpha_0$$

Critical alpha values

$$\boxed{\alpha = \frac{\alpha_0}{D_0} D}$$

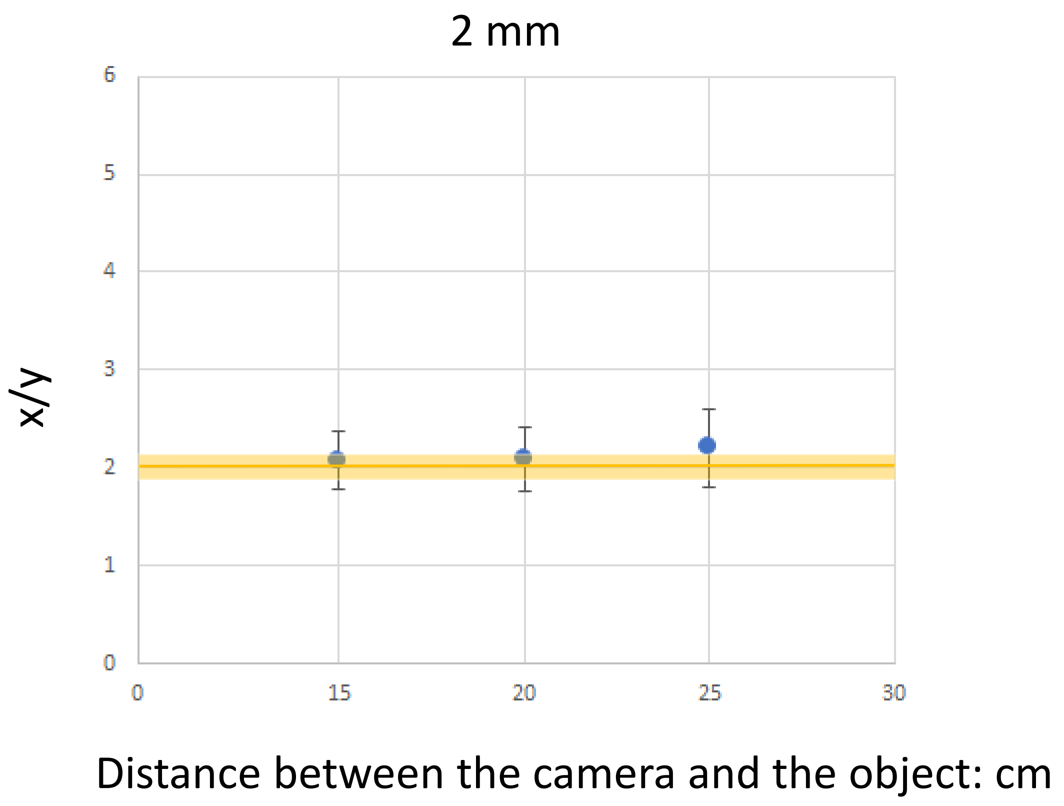
Data analysis

Comparison of the theoretical and experimental results

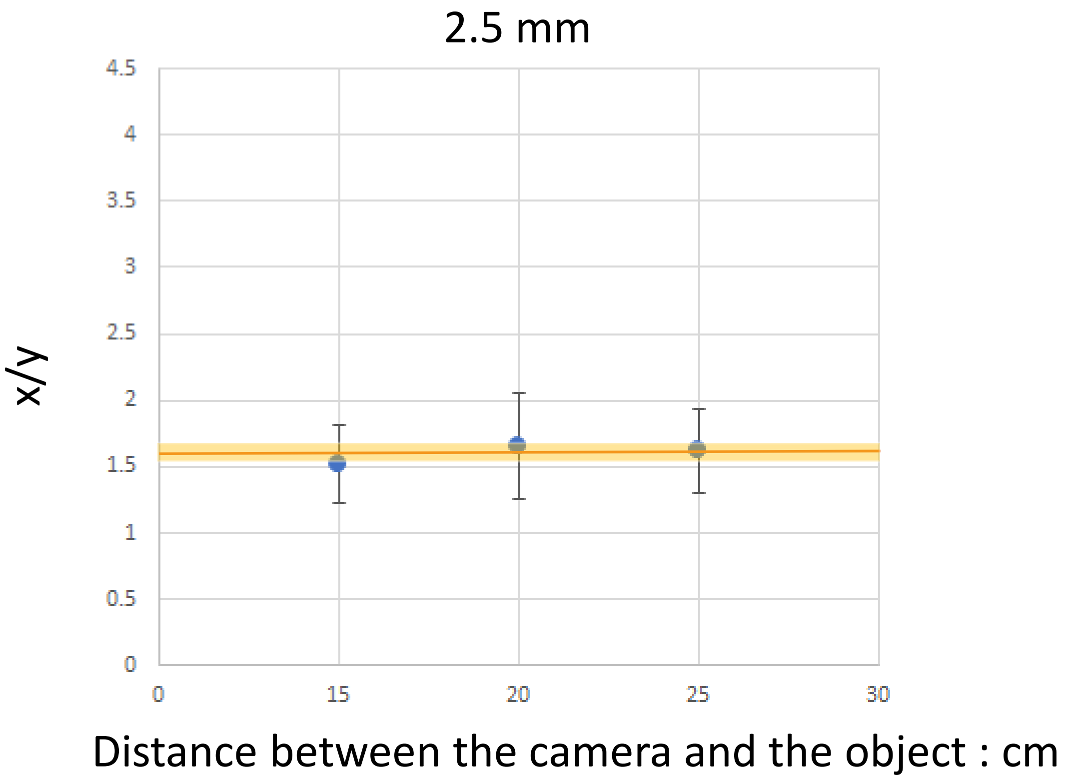
Theoretical calculation

$$\frac{GQ}{D} = \frac{b-a}{c-a} = \frac{4}{2} = 2$$

$$GQ = 4\,mm$$
$$D = 2\,mm$$



Comparison of the theoretical and experimental results

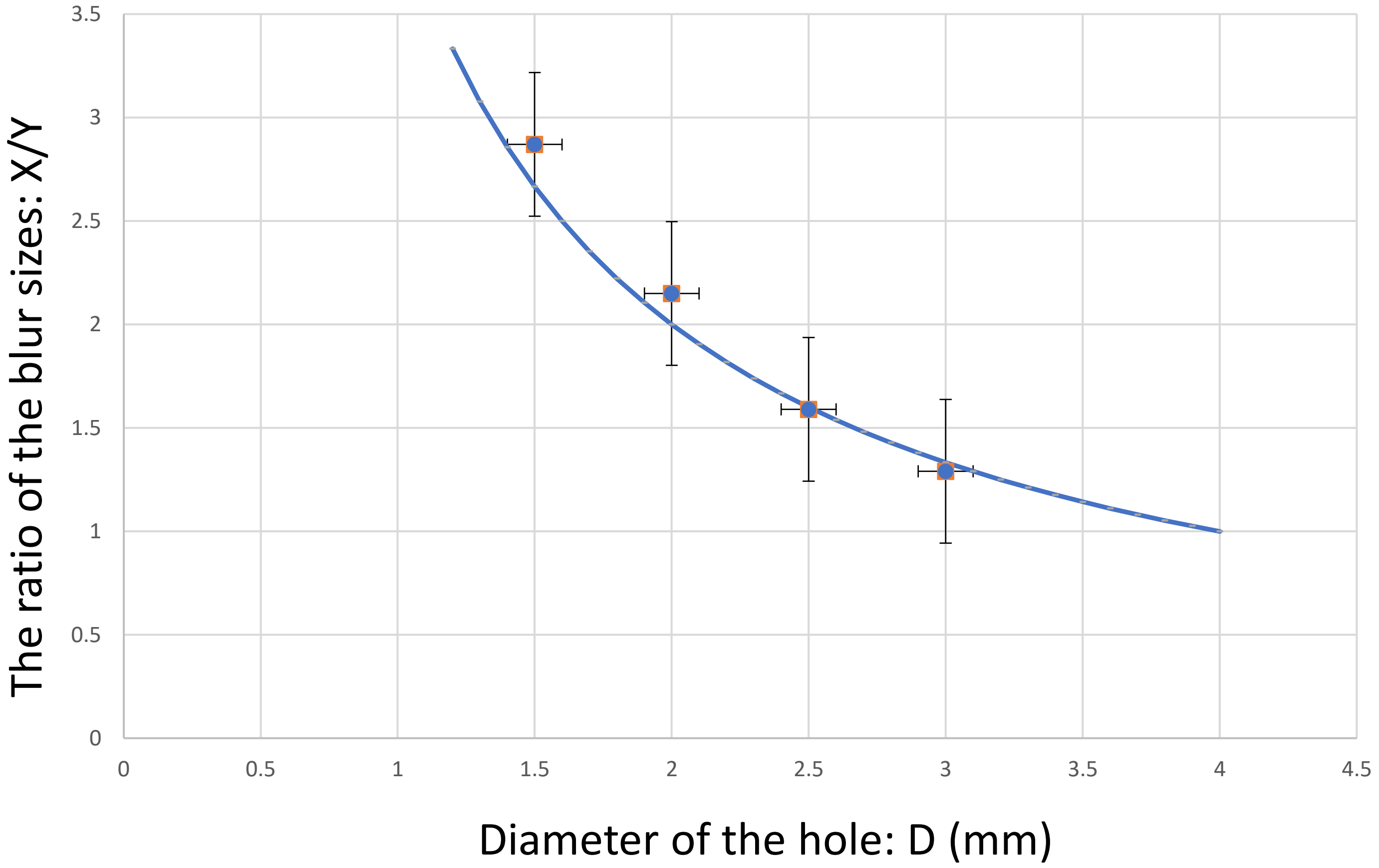


Theoretical calculation

$$\frac{GQ}{D} = \frac{b-a}{c-a} = \frac{4}{2.5} = 1.6$$

$$GQ = 4\,mm$$
$$D = 2.5\,mm$$

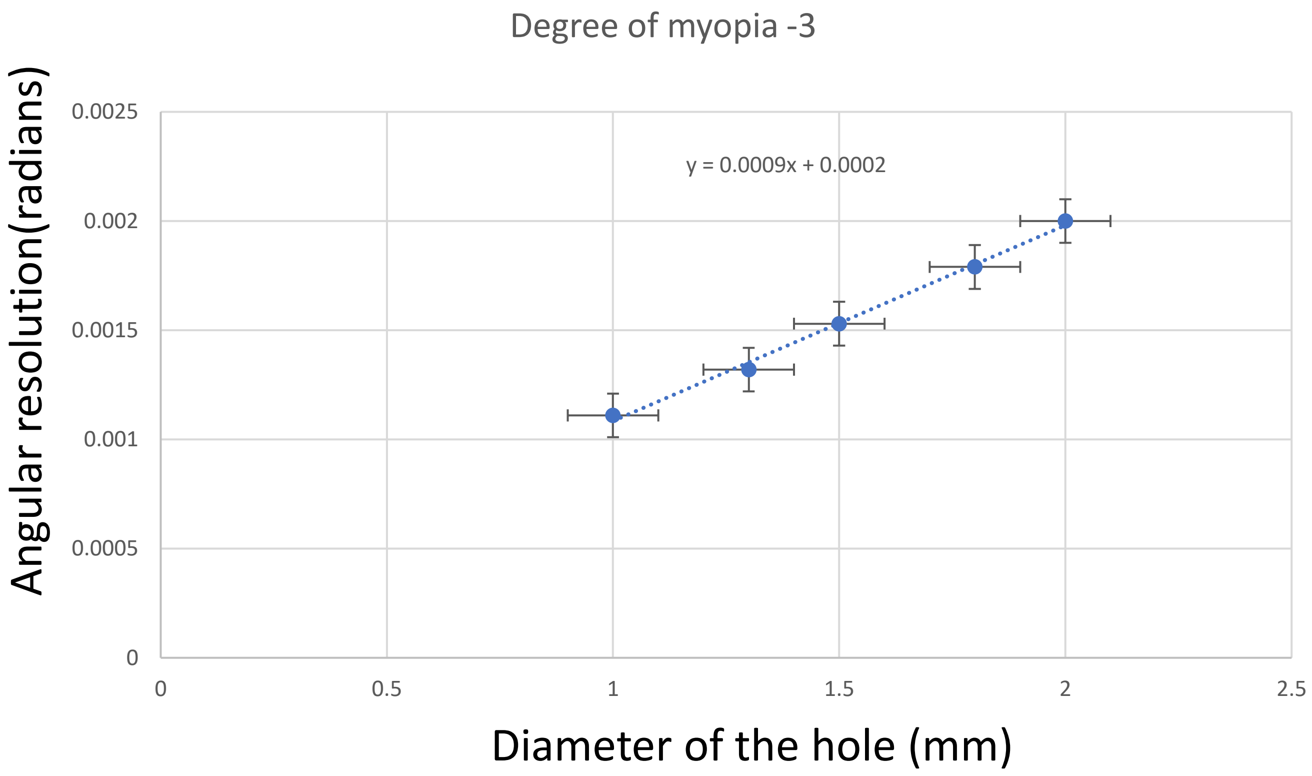
Comparison of the theoretical and experimental results



$$\frac{X}{Y} = \frac{D_0}{D}$$

$D_0 - diameter\ of\ camera\ lens: 4mm$

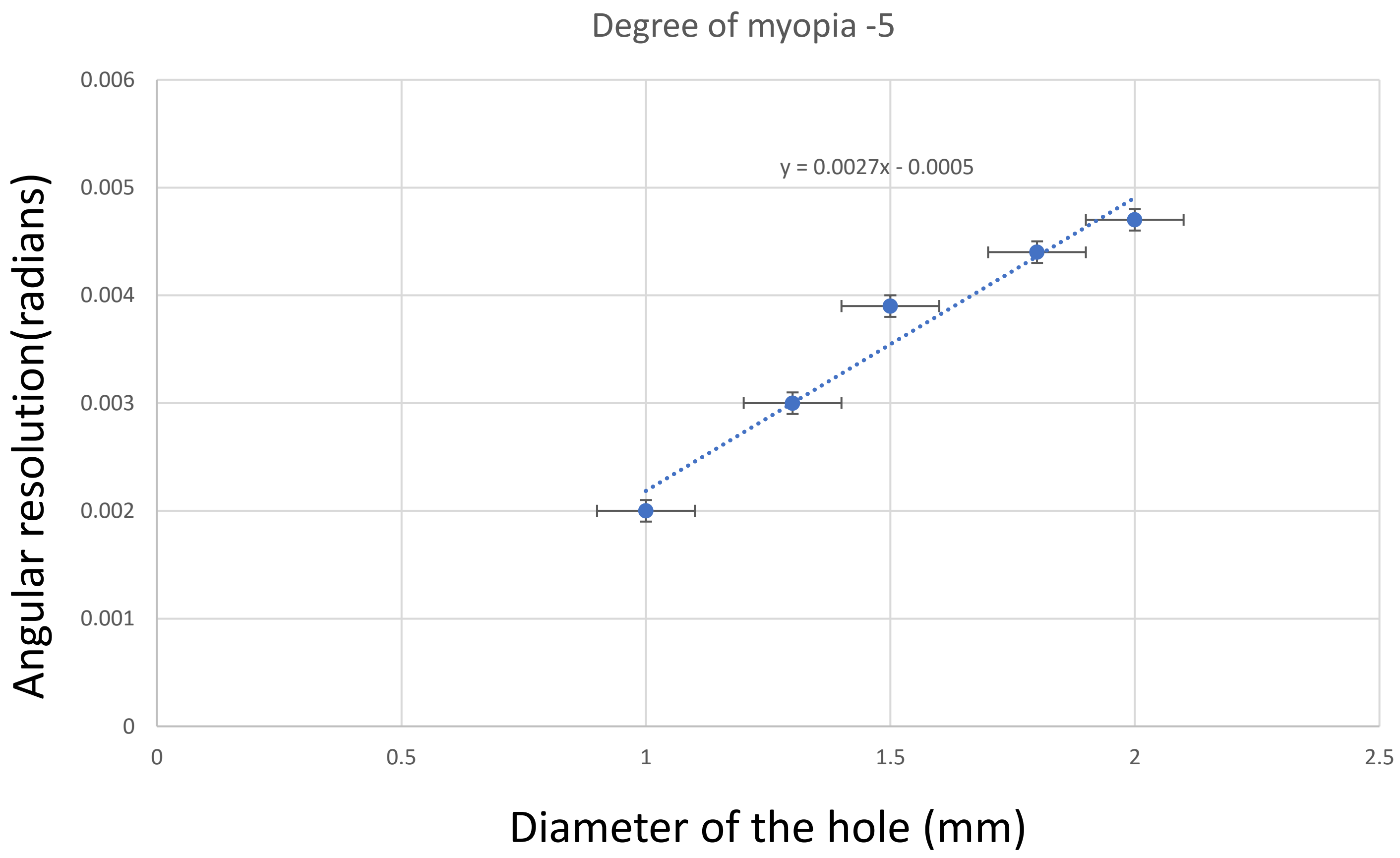
Experiments on the people



$$\alpha = \frac{\alpha_0}{D_0} D$$

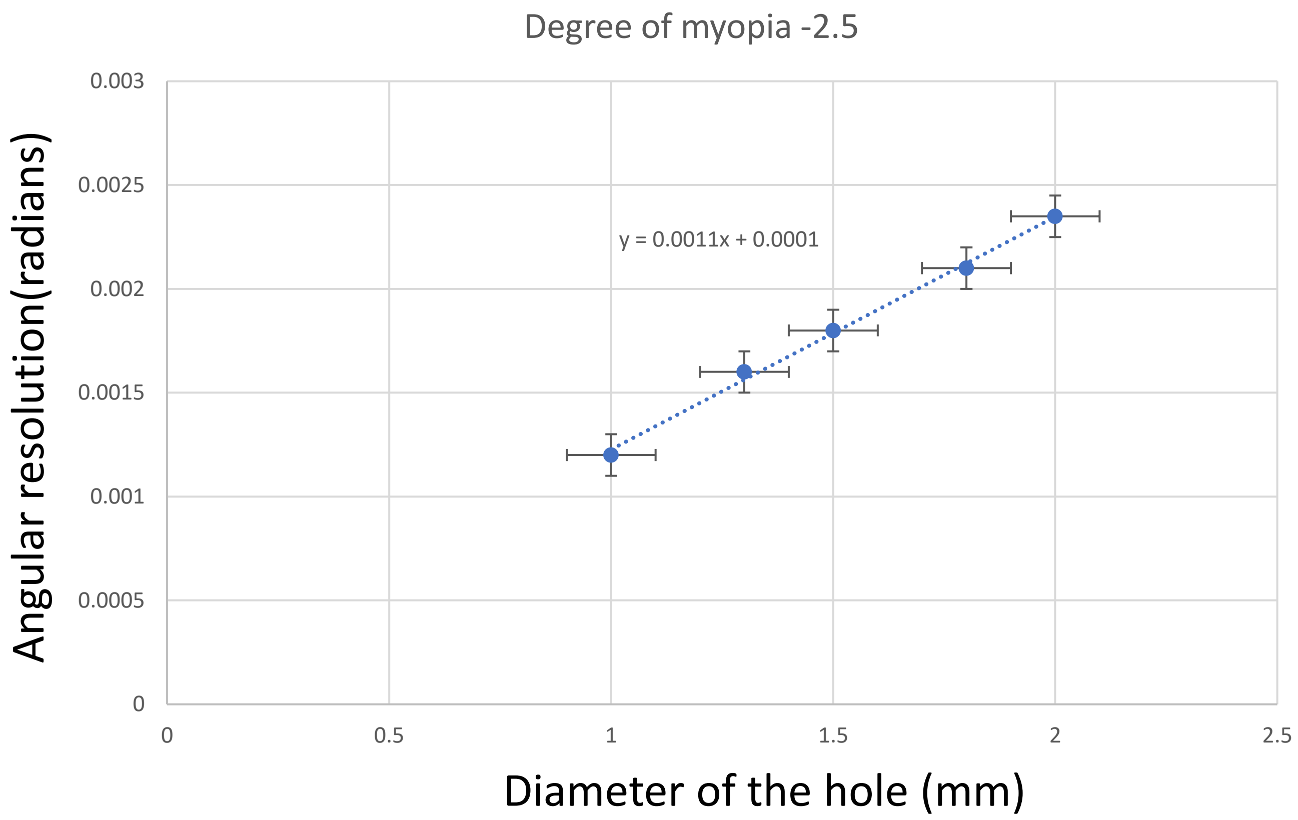
Phenomenon | Theoretical Model | Experiment | Conclusion

Experiments on the people



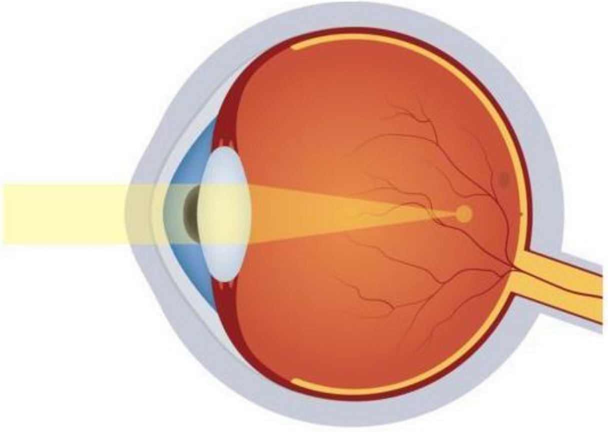
$$\alpha = \frac{\alpha_0}{D_0} D$$

Experiments on the people

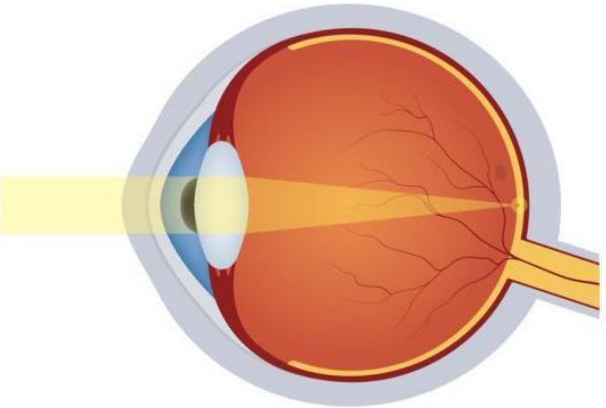


$$\boxed{\alpha = \frac{\alpha_0}{D_0} D}$$

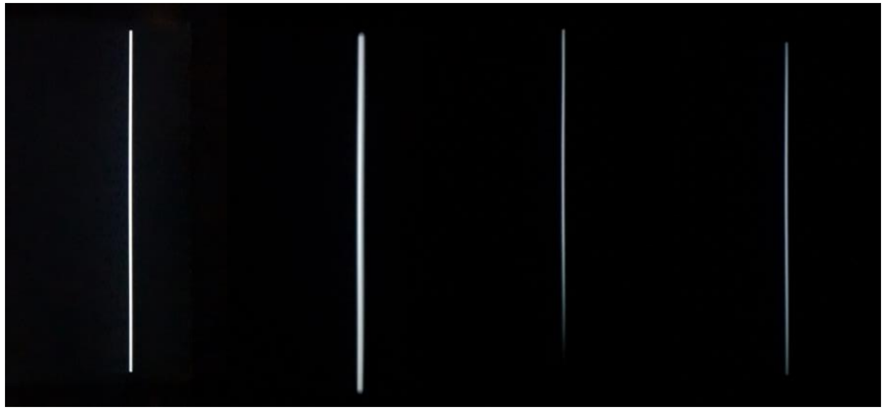
Conclusion



Myopic



Normal Vision

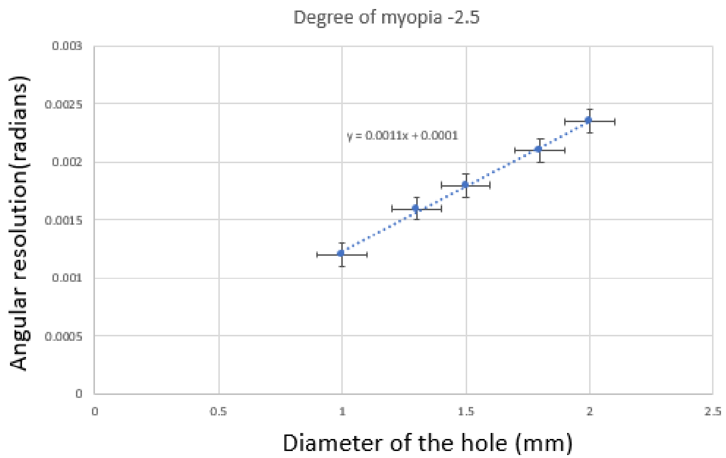


$$\frac{X}{Y} = \frac{D_0}{D}$$

$$\alpha = \frac{\alpha_0}{D_0} D$$

Important factors:

- Diameter of the hole;
- Controlled environment;
- Degree of myopia;



Thank you for your attention!