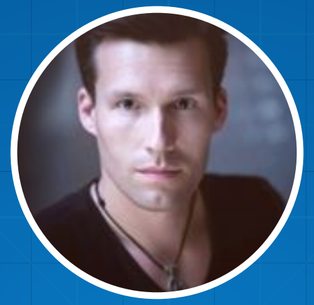


Matt Jaskulski, Ph.D.

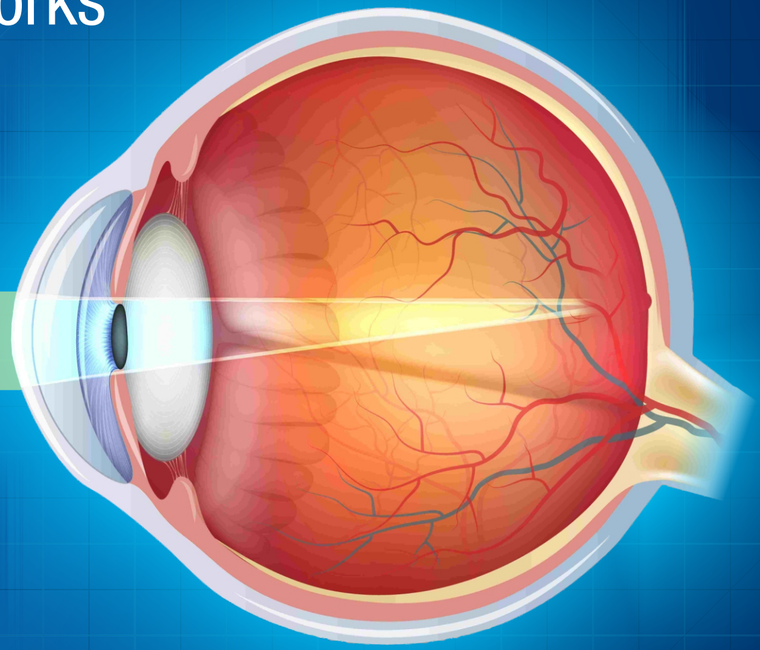
INDIANA UNIVERSITY
SCHOOL OF OPTOMETRY

UNIVERSIDAD DE
MURCIA

Slides, Video and Code: www.matt-jaskulski.com.

And now for something completely different... (hopefully)

- A glance at machine learning and neural networks
- Face detection demonstration
- What is Myopia, Prevalence in the World
- Myopia as "Nature vs Nurture" Challenge
- Face Detection Applied to Myopia Research
- Overview of technologies involved.

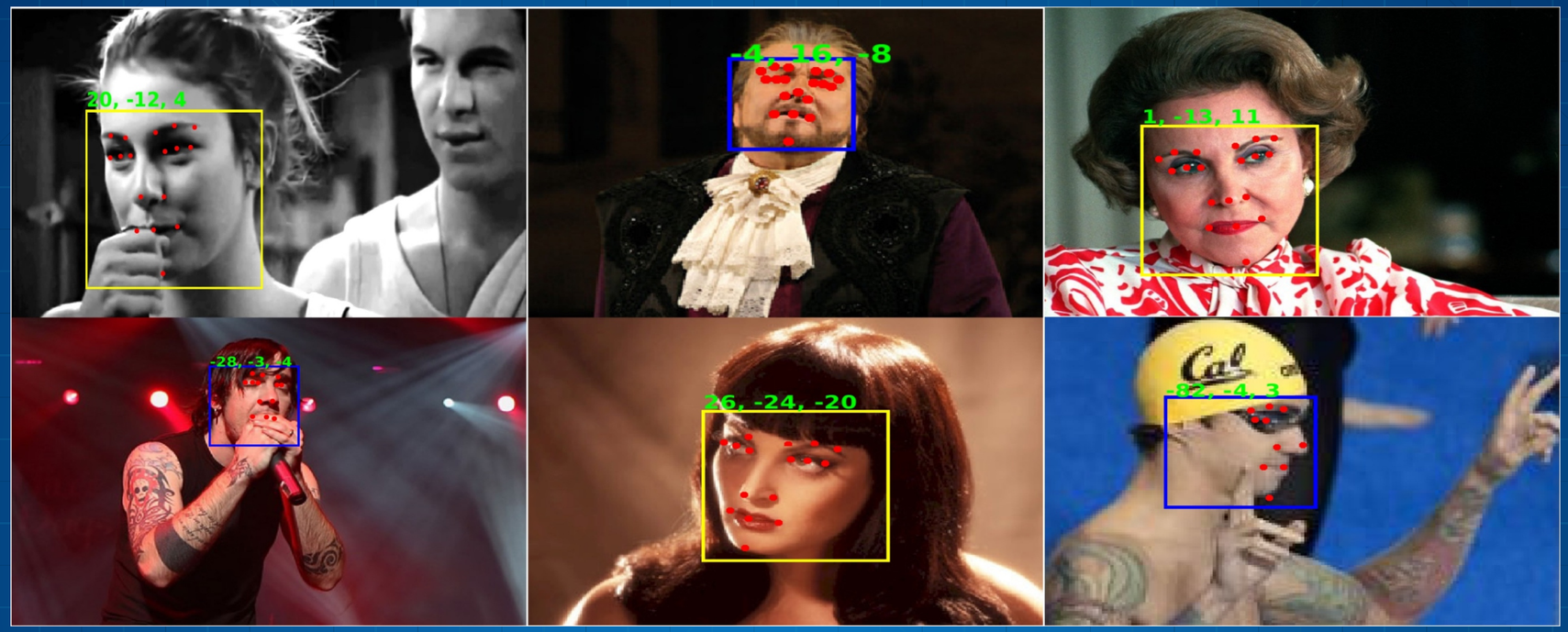


TensorFlow

Google releases Android 8.1 developer preview with Neural Networks API

Image Generated by: PIXComposer.com

Android Studio



http://www.umdfaces.io/ 367,888 face annotations for 8,277 subjects

MS-Celeb-1M 1 000 000 faces of celebrities

CASIA 453,453 images for over 10,575 identities

Videos Sources:

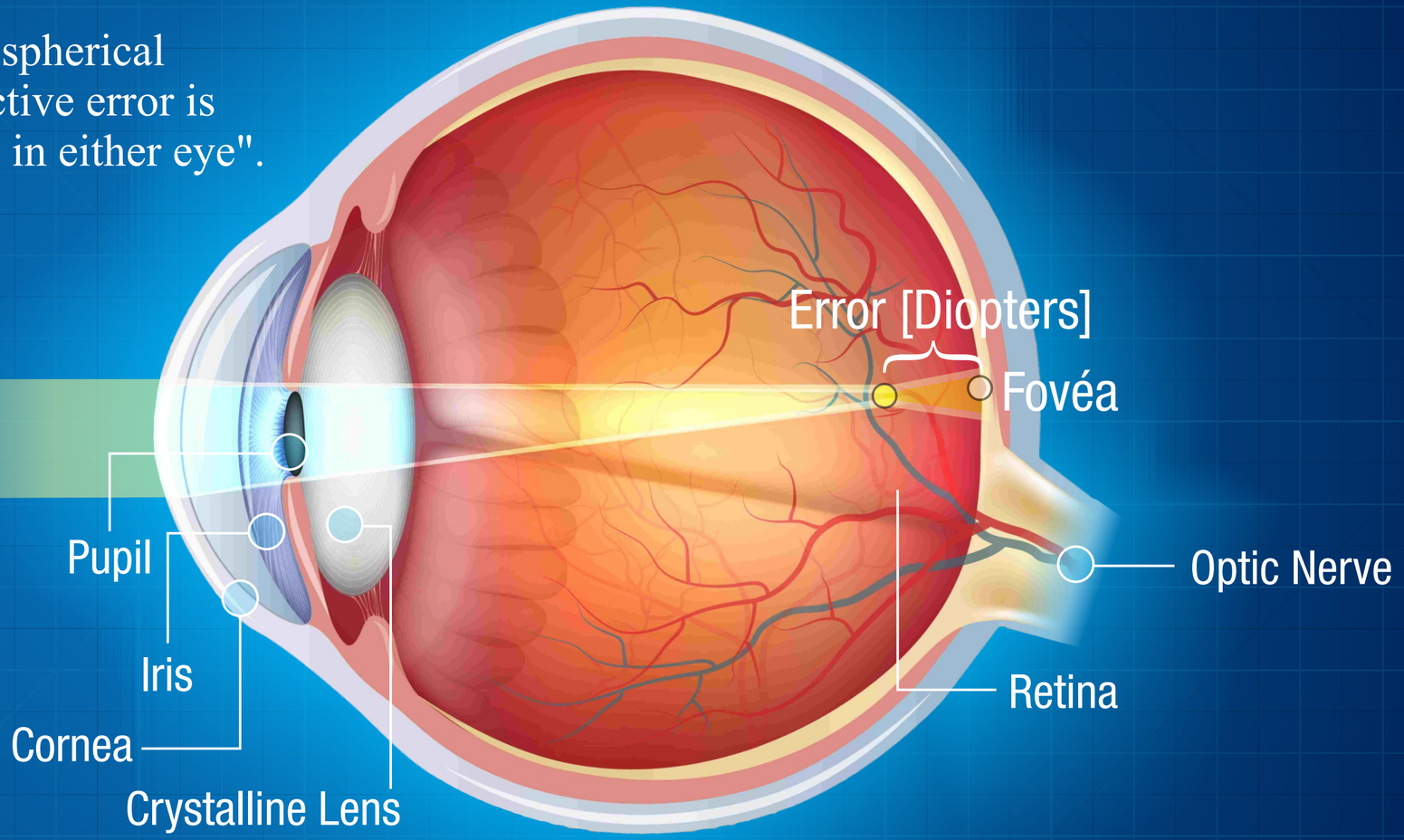
YouTube: Diegocavalca, 3Blue1Brown

CITYSCAPES DATASET

Myopia

"A condition in which the spherical equivalent objective refractive error is ≤ –0.50 diopter (– 0.50 D) in either eye".

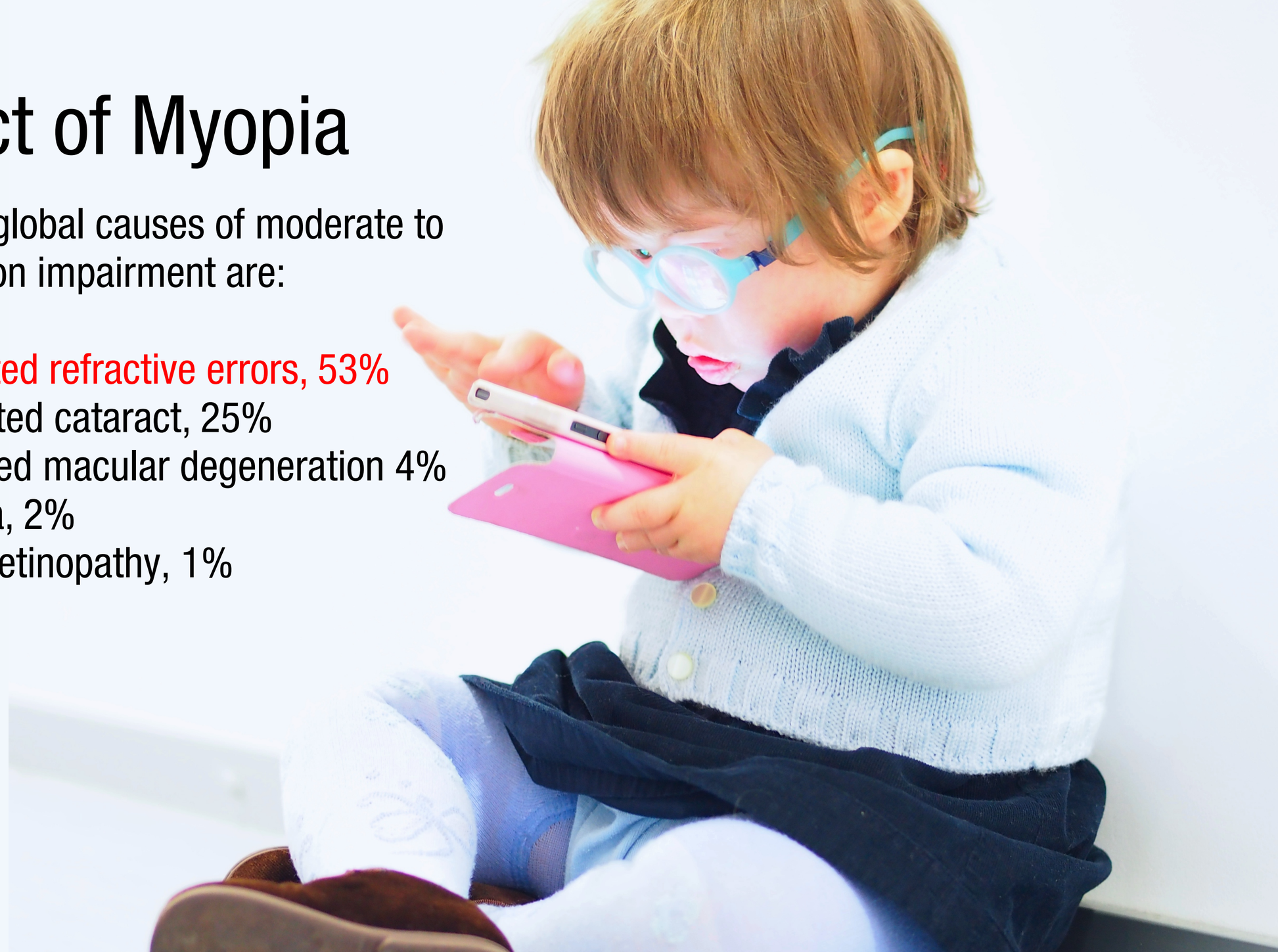
World Health Organization



Impact of Myopia

The major global causes of moderate to severe vision impairment are:

- uncorrected refractive errors, 53%
- un-operated cataract, 25%
- age-related macular degeneration 4%
- glaucoma, 2%
- diabetic retinopathy, 1%



Impact of High Myopia

The major causes of blindness are:

- un-operated cataract 35%
- uncorrected refractive error 21%
- glaucoma, 8%.

High Myopia

"A condition in which the spherical equivalent objective refractive error is ≤ –5.00 D in either eye

World Health Organization

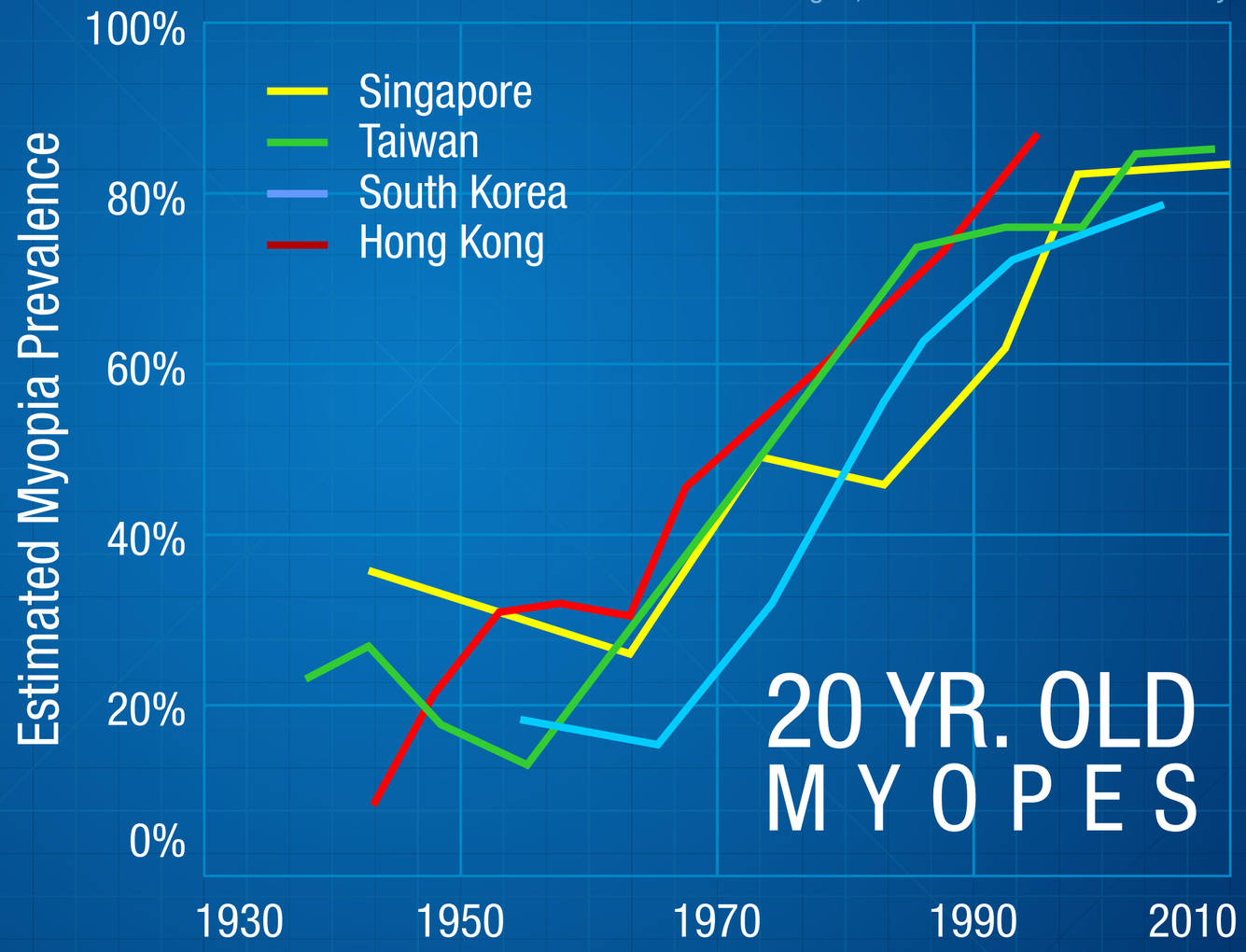
Estimated US$ 148 per child per year.
Total cost in Asia US$ 328 billion.

The Rise of Myopia First Occurred in Asia

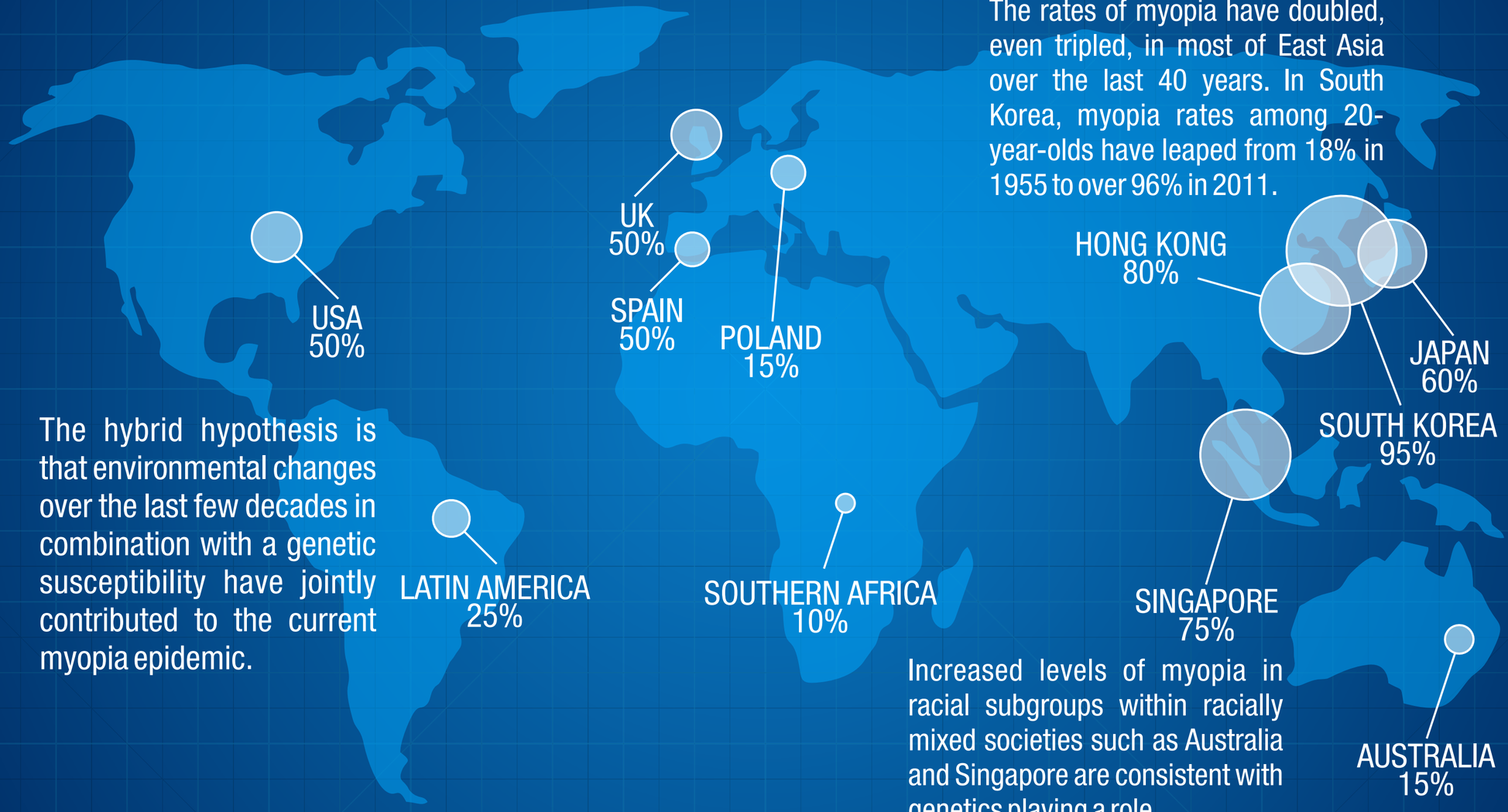
Ian Morgan, Australian National University

The rapid increase in myopia prevalence seen over the last decades implicates a change in the environment as the primary causal agent for the current global epidemic.

However, very high prevalence, early onset, and high levels in Asia, and familial clustering of myopia are consistent with genetics playing a significant role.



Myopia Prevalence is Increasing Worldwide



The rates of myopia have doubled, even tripled, in most of East Asia over the last 40 years. In South Korea, myopia rates among 20-year-olds have leaped from 18% in 1955 to over 96% in 2011.

The hybrid hypothesis is that environmental changes over the last few decades in combination with a genetic susceptibility have jointly contributed to the current myopia epidemic.

Increased levels of myopia in racial subgroups within racially mixed societies such as Australia and Singapore are consistent with genetics playing a role.

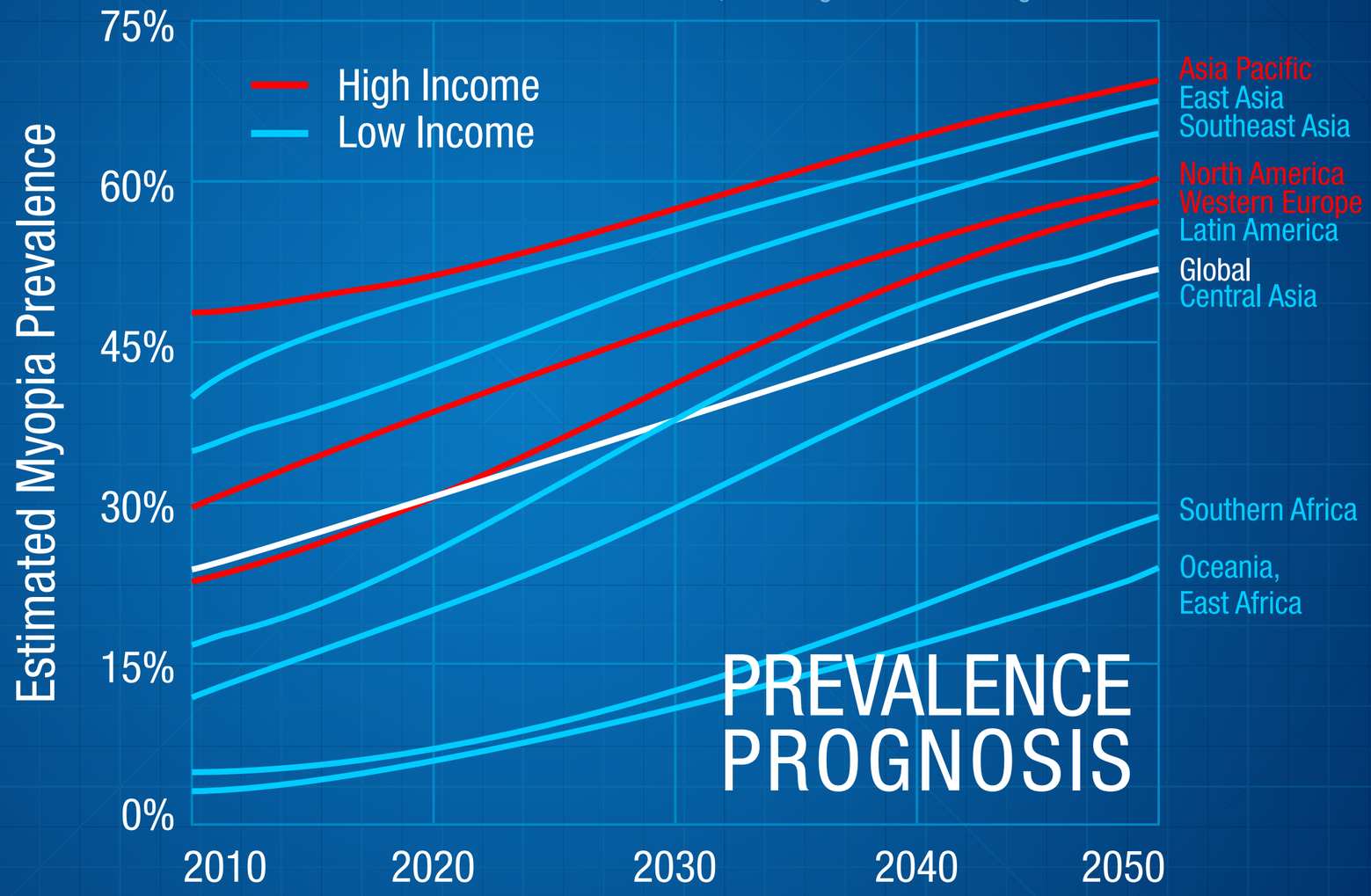
Brien Holden Vision Institute (BHVI), published in Ophthalmology in 2016. Meta Analysis, 147 studies included.

Prevalence is Correlated with Wealth and Education

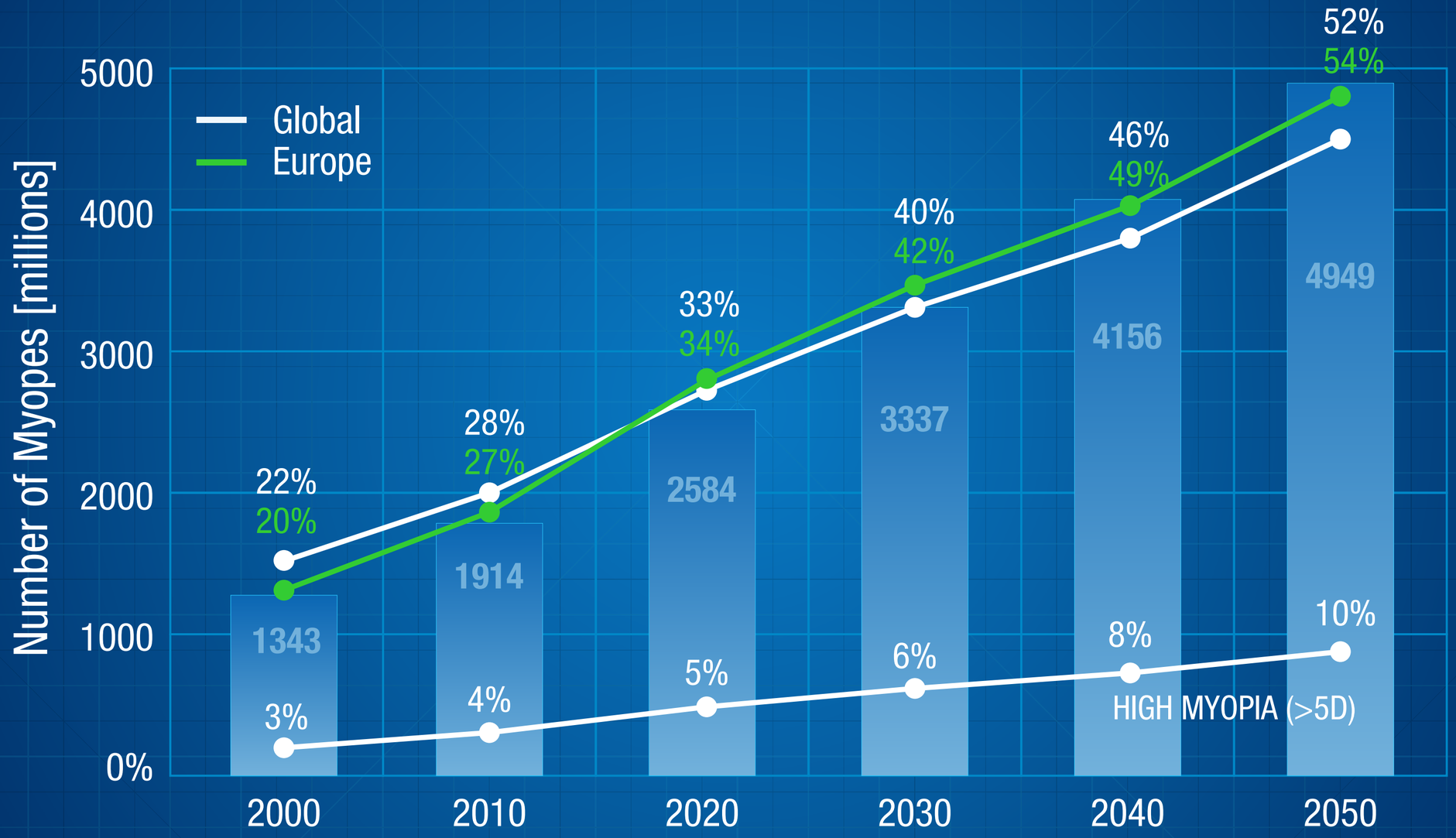
The prevalence of myopia in a given region tends to rise with income, probably because people with more wealth spend more time indoors.

The first evidence of a myopia epidemic came from Asia, where high intensity education may be contributing to the rapid rise.

Scientific American, “Soaring rates of near-sightedness”.



Half of the World Population Myopic by 2050



Brien Holden Vision Institute (BHVI), Holden, Fricke, Wilson, Jong, Naidoo, et al. 2015.

If we do not find a treatment, predictions suggest that 1 in 2 of the world's population will be myopic by 2050. 5 Billion people!

Meanwhile…

The average time spent daily with mobile devices has tripled since 2013. Children eight and under spend on average 2.3h daily with screen media.

Myopia is Caused by Excessive Axial Elongation

Grosvenor, 1994

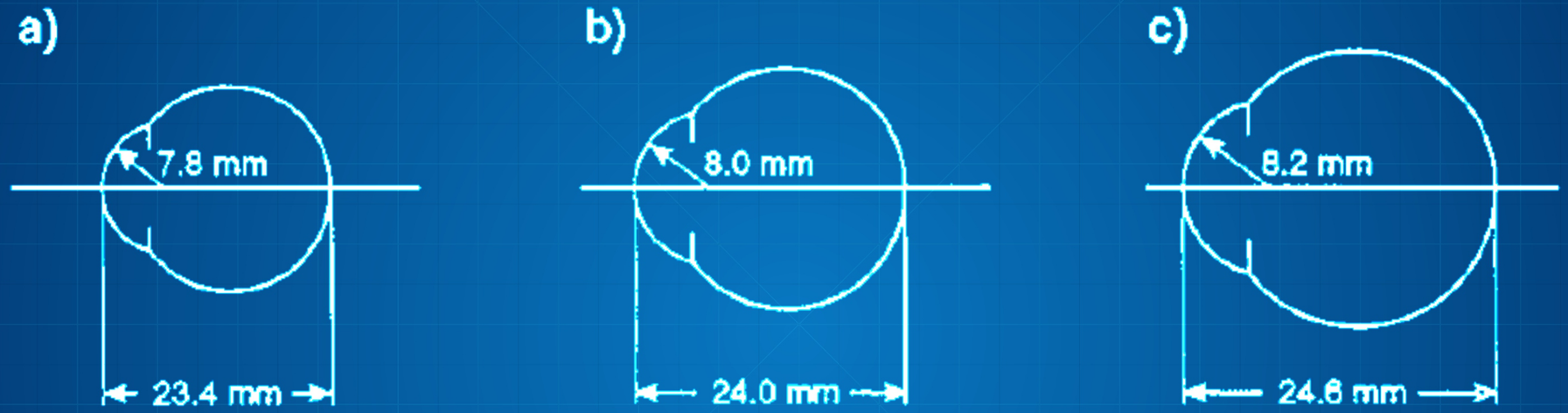


Figure 1. Three schematic eyes, all having an AL/CR ratio of 3.0, all of which would be expected to be emmetropic.

Grosvenor: as the ratio AL/CR increases, the eye becomes more myopic.

Myopia is Caused by Excessive Axial Elongation

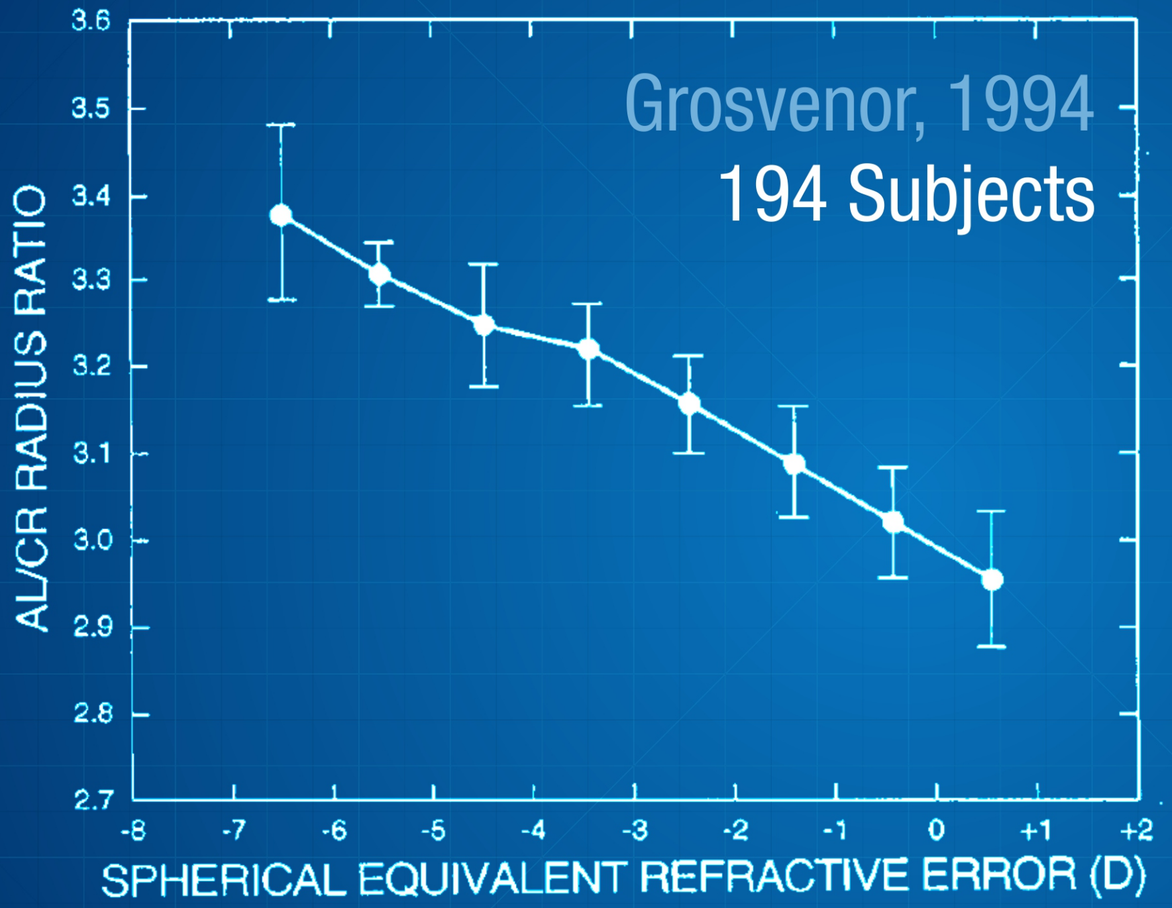
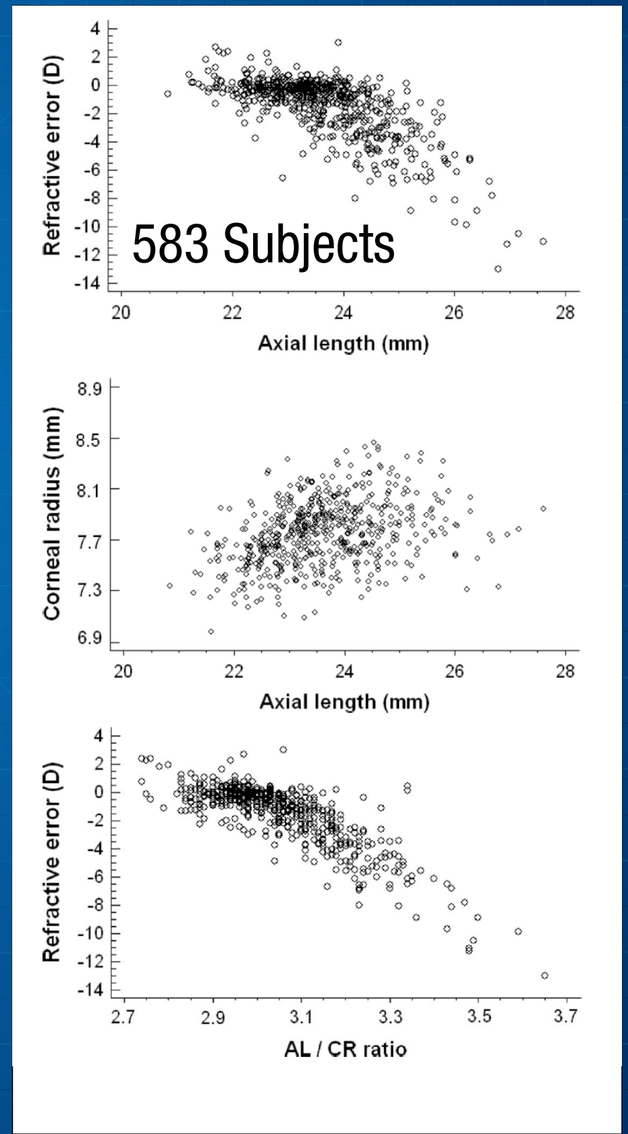
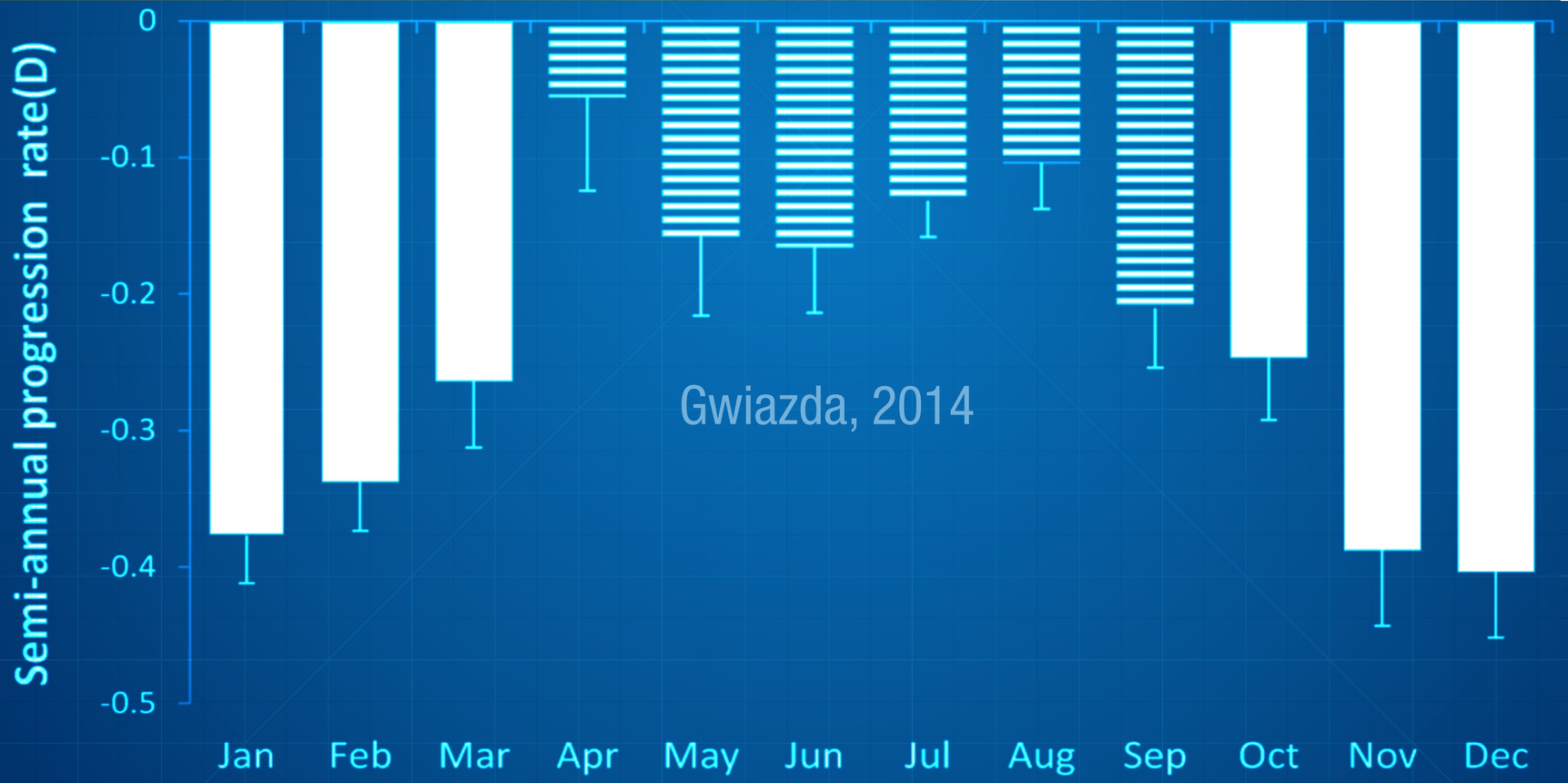


Figure 5. Mean AL/CR ratio as a function of mean spherical equivalent refractive error, for right eyes of 194 subjects between the ages of 18 and 30 years.

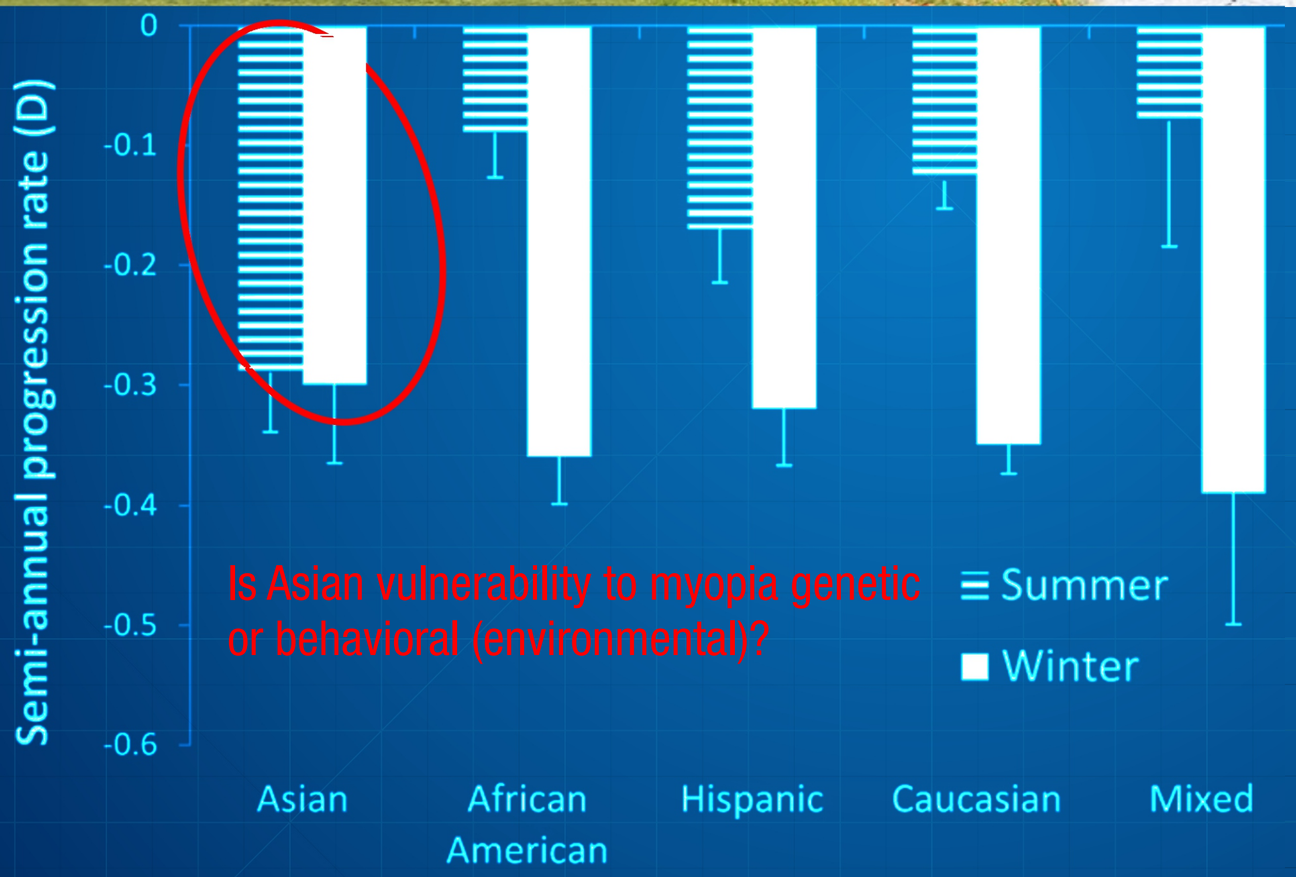
Blanco, 2008



Myopia progresses more slowly in the summer months



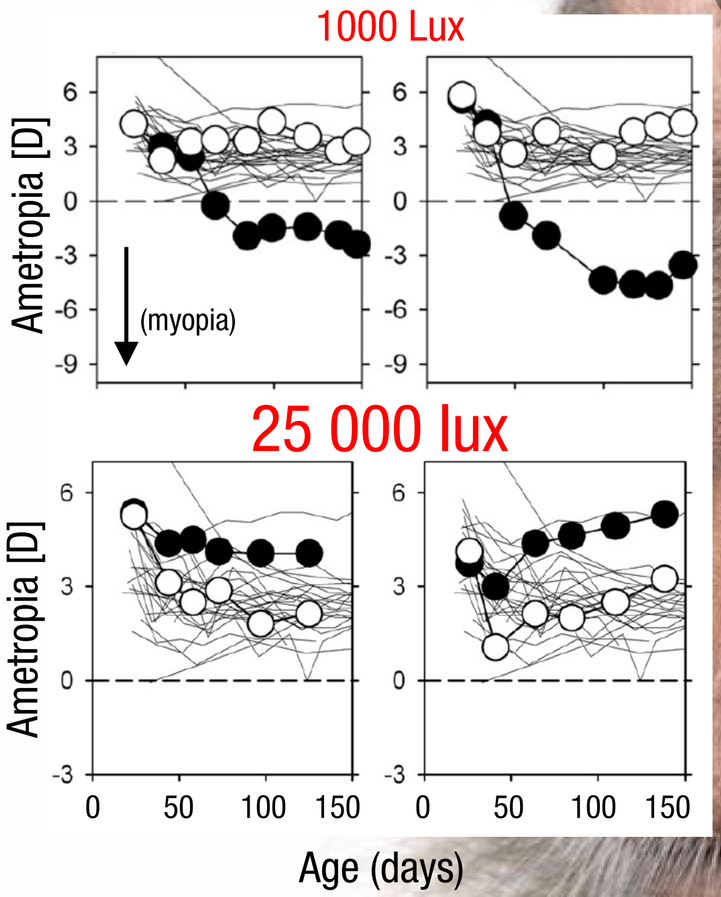
Myopia progresses more slowly in the summer months



Holden, 2016

Among environmental factors, so-called high pressure educational systems, especially at very young ages in countries such as Singapore, Korea, Taiwan, and China, may be a causative lifestyle change, as may the excessive use of near electronic devices.

High Light Levels Protect Against Form Deprivation Myopia In Rhesus Monkeys

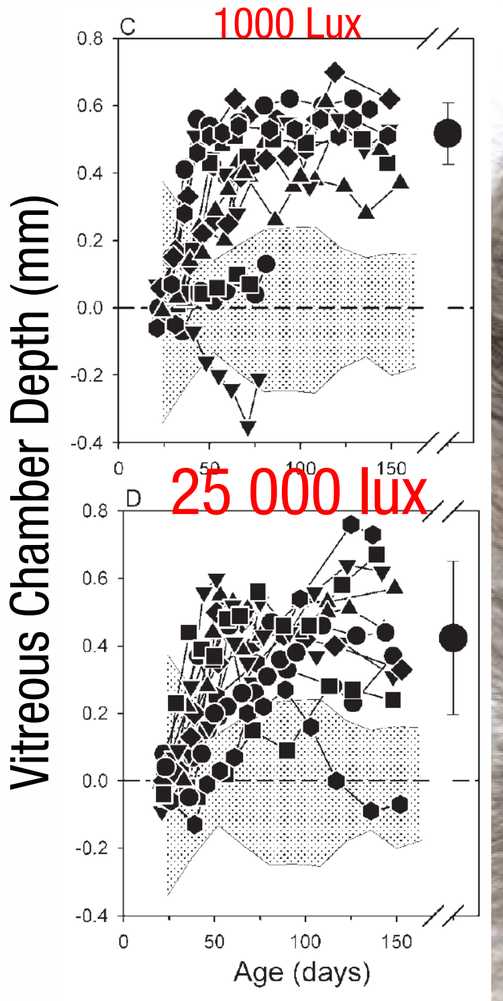


Optical Scattering Lenses in One...

...no Treatment in Other Eye

"Protective Effects of High Ambient Lighting on the Development of Form-Deprivation Myopia in Rhesus Monkeys"
Smith 2012

High Light Levels DO NOT Protect Against Hyperopic Defocus Myopia In Rhesus Monkeys

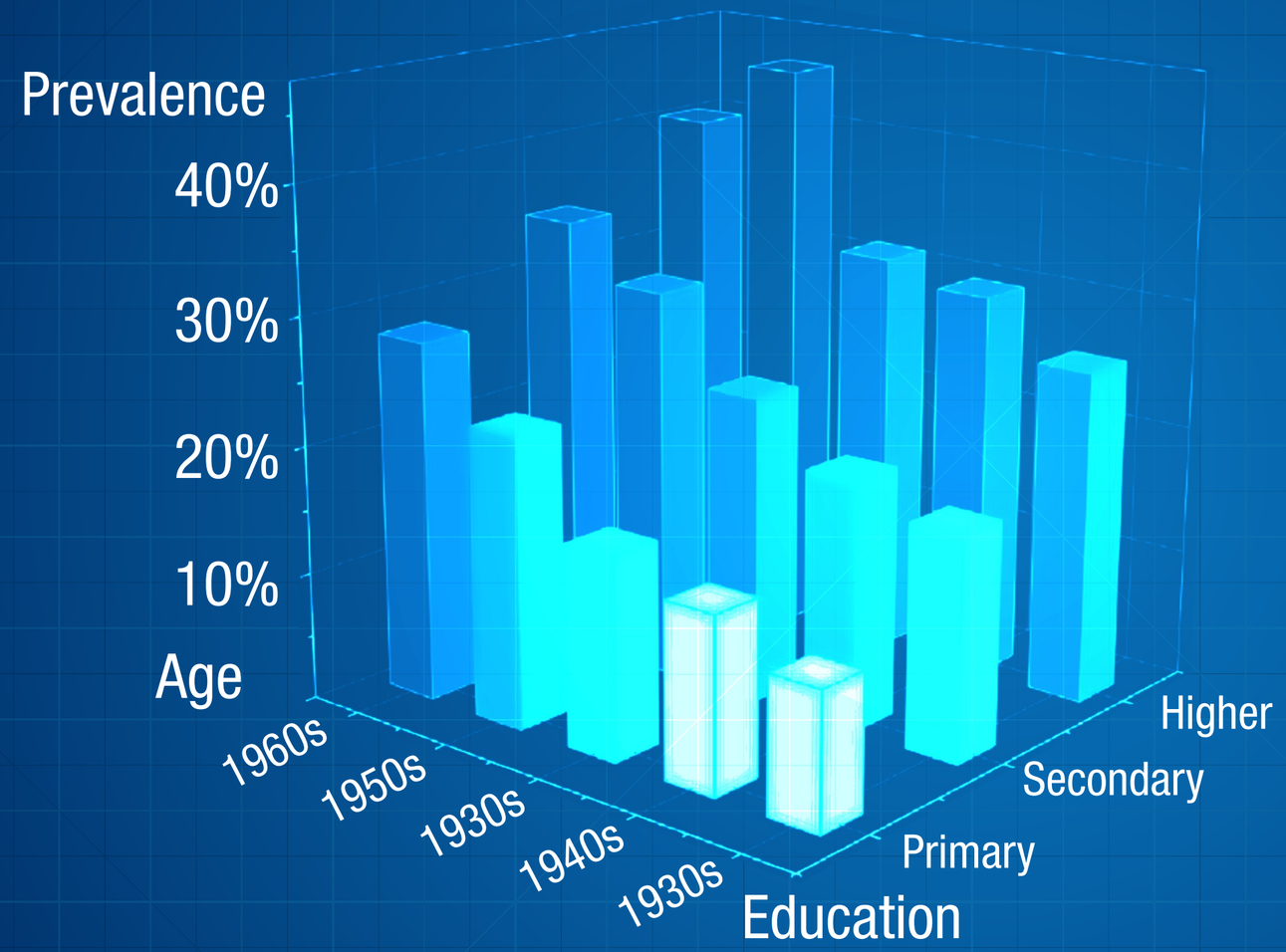


(-) Lens in One Eye...

...no Treatment in Other Eye

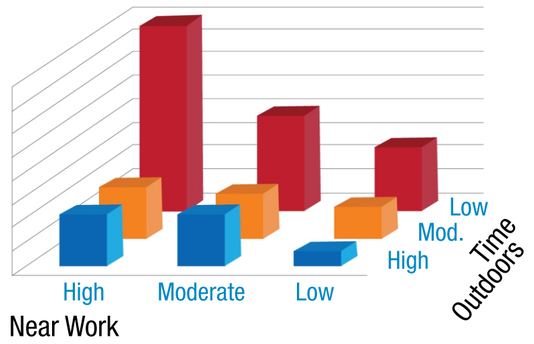
"Negative Lens–Induced Myopia in Infant Monkeys: Effects of High Ambient Lighting"
Smith 2013

Education, Time Outdoors and Age Affect Prevalence



Myopia in Europe: Williams, 2015, 124,000 patients

French et al., 2013



- Children who spend more time outdoors are less likely to be or become myopic.
- This protection appears to be due to time outdoors, rather than engagement in sport.
- Effect sizes suggest that more time outdoors could reduce myopia in children.
- Dopamine release may be stimulated by bright outdoor light, inhibiting eye growth.
- It is not clear whether time outdoors slows progression of myopia.

“Nature vs Nurture” Challenge

Nature:

Determined by the environment

- Rapid increase in prevalence over the last decades (something changed in environment? What characteristics are responsible?),
- The retina plays the central retinal role in regulating eye growth (animal studies show). Retina-specific environmental factors contribute to myopia development in humans, and retinal deprivation from ptosis/cataract).
- It is likely, that changes in the light environment (intensity, spectral content, optical distance) have an effect, rather than non-visual factors such as air pollution and diet.

Nurture:

Determined by a person's genes

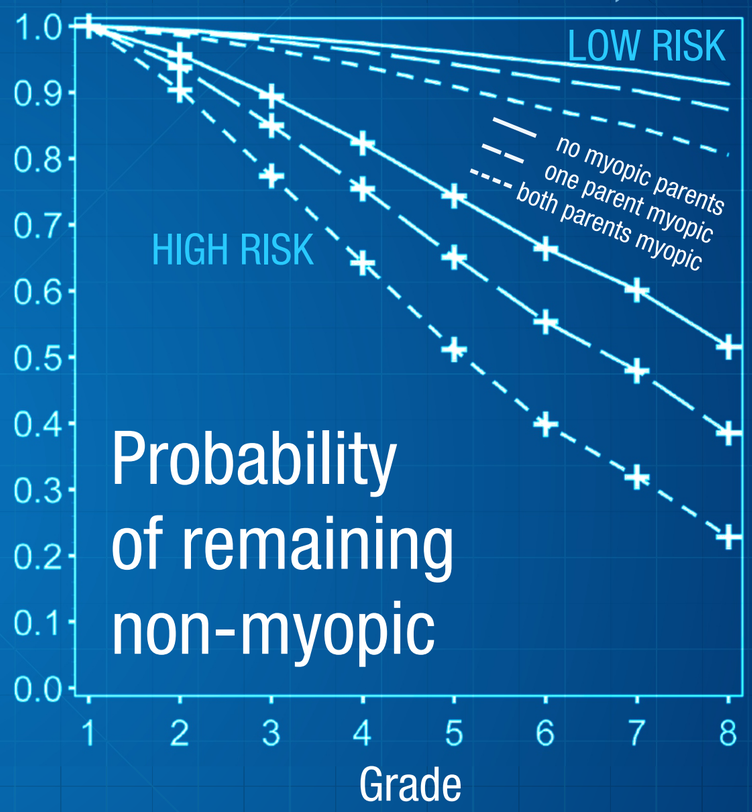
- Familial clustering of myopia, myopic parents a risk factor for myopia development in children.
- High severity (e.g. very high prevalence, early onset, and high levels) in East Asia,
- Increased levels of myopia within racial subgroups in mixed societies like Australia and Singapore (genetics?).

homeostatic failure or... success?

“Nature vs Nurture” Challenge

- Covariance of many factors, (more time outside will always be negatively correlated with less time inside).
- Activities are generally different in the indoor and outdoor environments.
- Important interventions (e.g. spectacle or contact lenses) are common/standard during the progressing phase of myopia, and alter the retinal environment.
- Myopia development is slow (typically <1.0 D per year), and refractive measures have coefficients of repeatability of about this magnitude (multi-year monitoring)
- Accurate measures of the multidimensional properties of the visual environment (light level, viewing distance) experienced by children are difficult to obtain.

Jones et al., 2007



Most important risk factor:
refractive status at age 5 (1st grade)

HIGH RISK: Rx < 0.75D LOW RISK: Rx >= 0.75D

If only there was a device with all kinds of sensors,
which everyone (kids) had on them all the time,
capable of measuring light levels,
view distance and
even refraction
in real time...

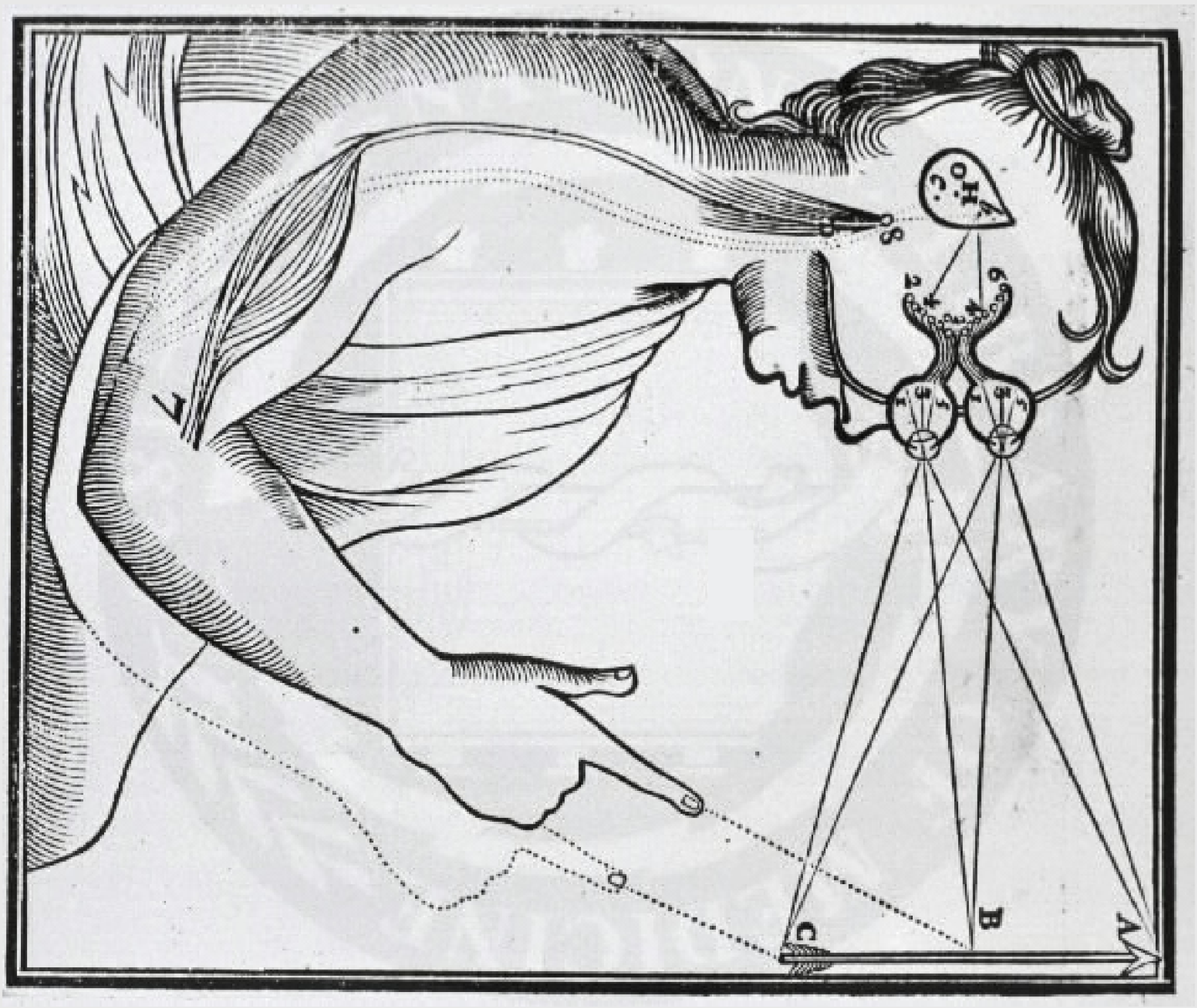
If only there was a device with all kinds of sensors,
which everyone (kids) had on them all the time,
capable of measuring light levels,
view distance and
even refraction
in real time...


CSI:
CRIME SCENE INVESTIGATION
Myopia

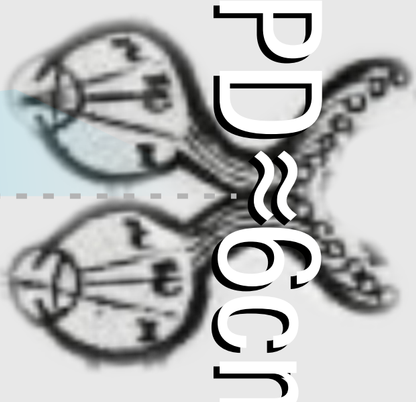

CSI:
CRIME SCENE INVESTIGATION
Myopia


FOV

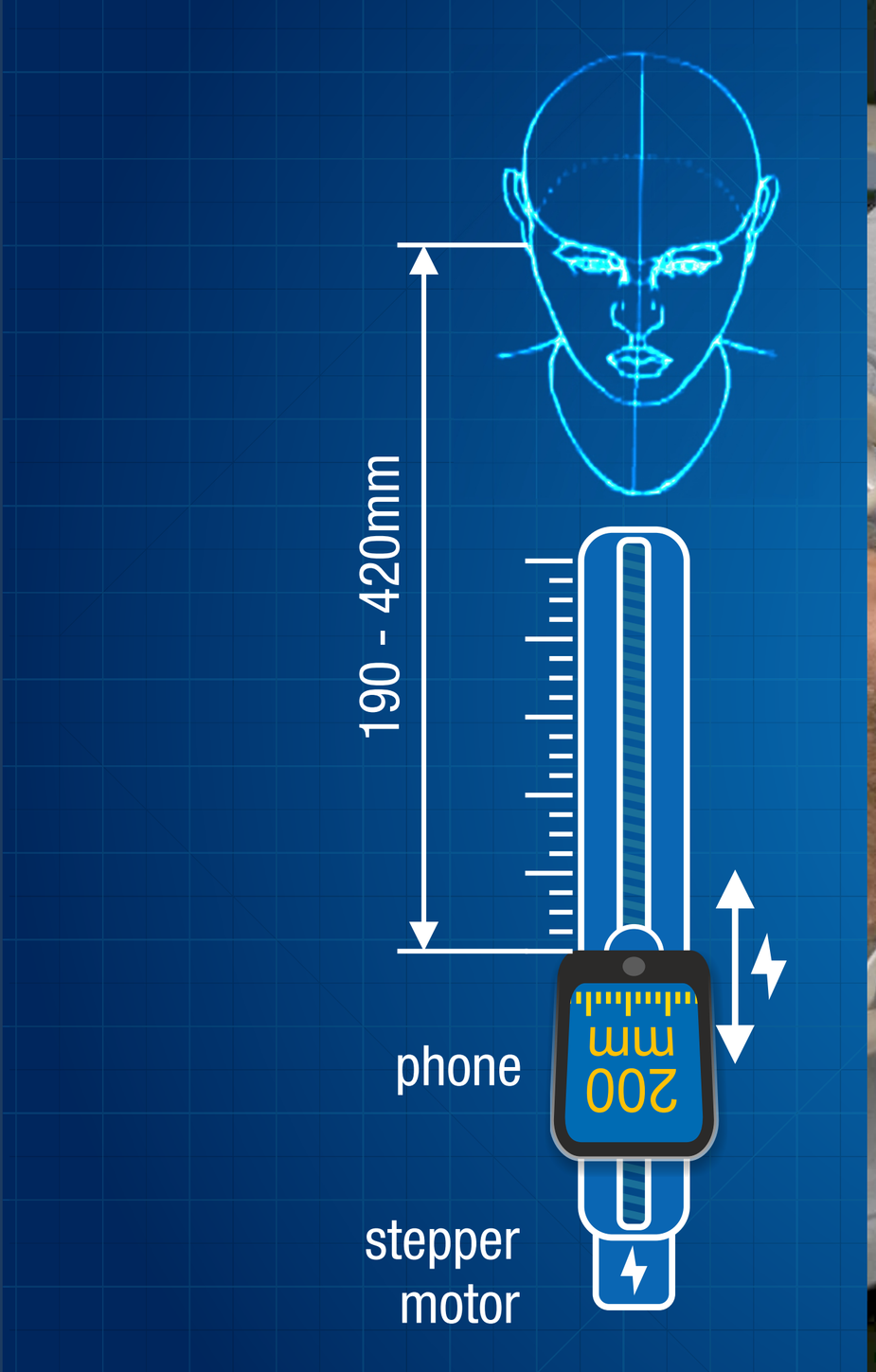

FACE ANGLE = FACE WIDTH [pix] * K [DEG/PIX]
K = FOV$_{CAMERA}$/N$_{PIXELS}$



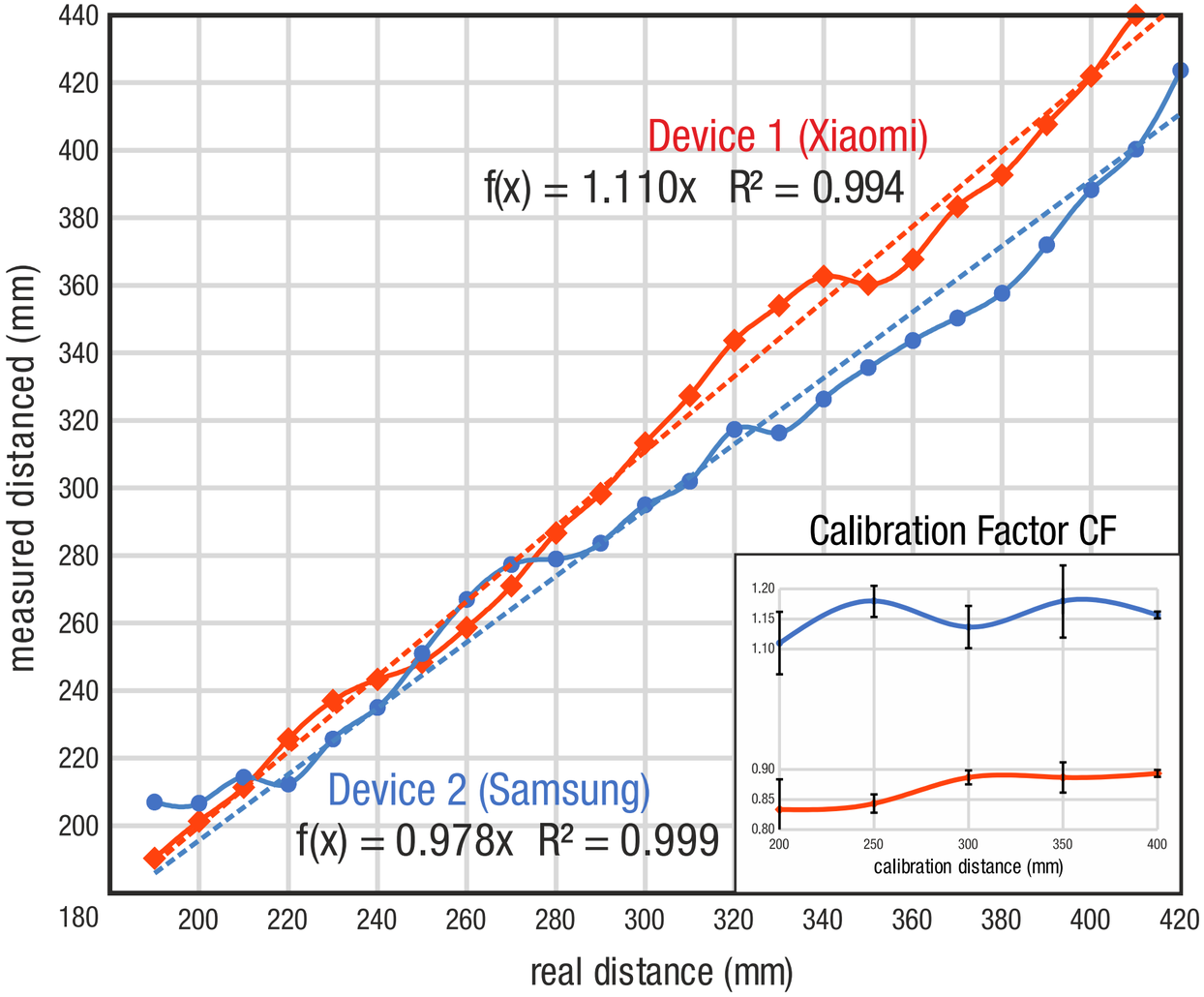
FACE ANGLE = arctg(IPD/D)



IPD≈63mm


190 - 420mm
200 mm
phone
stepper motor

Measured vs Real Distance



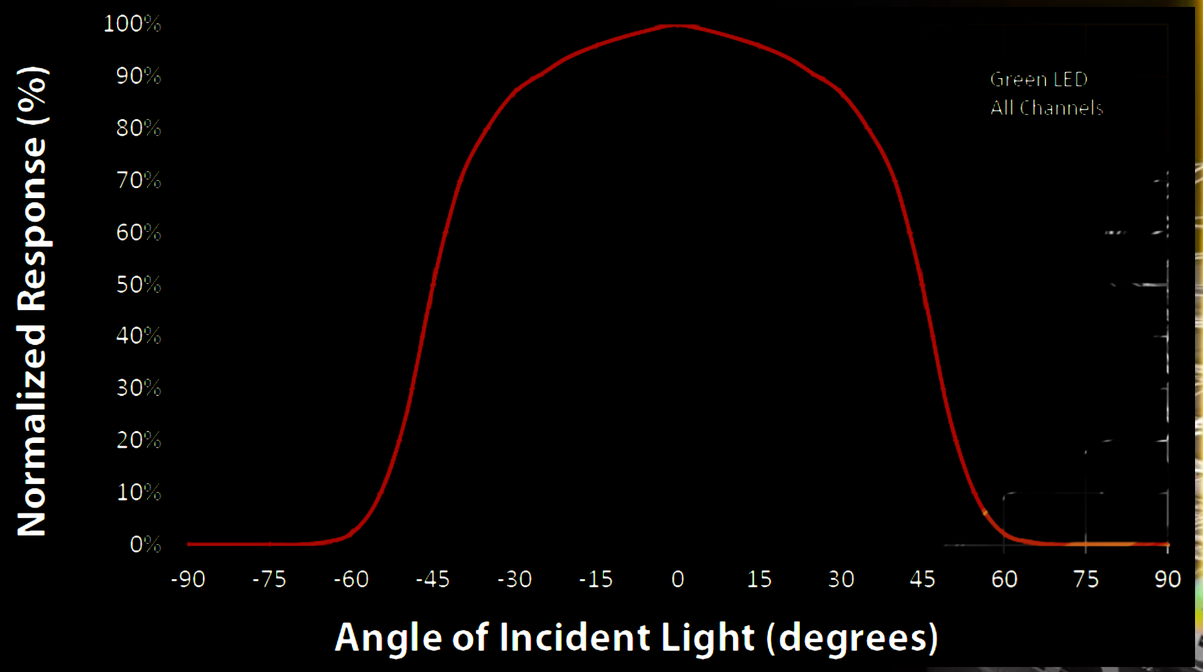

Measuring
Face Illuminance

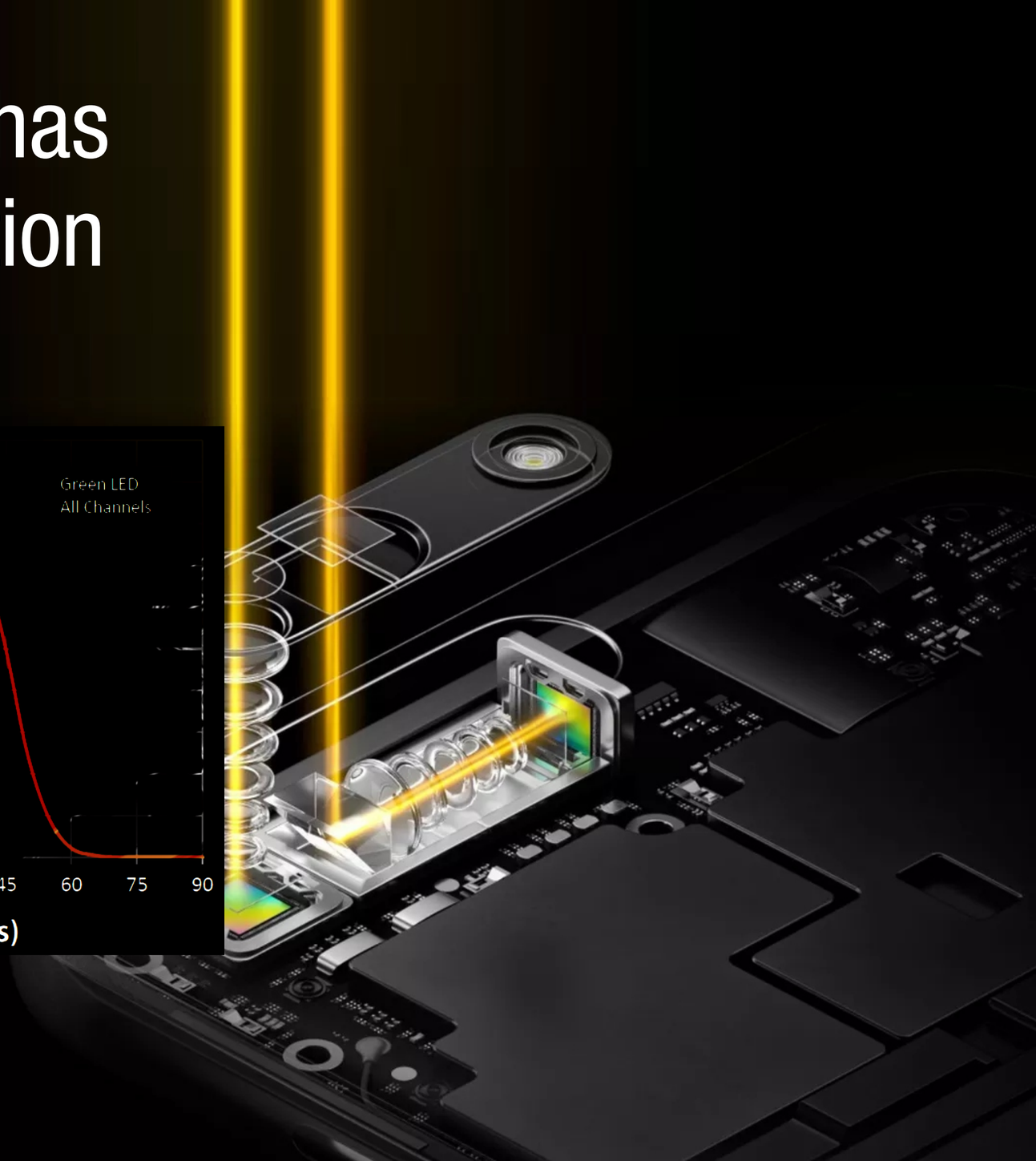
Let's Build a Simple Light Meter App

```
public class MainActivity extends AppCompatActivity implements SensorEventListener {
    private SensorManager mSensorManager;
    private Sensor mLight;
    private TextView tvReading;

    float currentLux = 0;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);

        mSensorManager = (SensorManager)getSystemService(SENSOR_SERVICE);
        mLight = mSensorManager.getDefaultSensor(Sensor.TYPE_LIGHT);
        tvReading = this.findViewById(R.id.reading);
    }

    public void onSensorChanged(SensorEvent event)
    {
        if( event.sensor.getType() == Sensor.TYPE_LIGHT) {
            currentLux = event.values[0];
            tvReading.setText(String.format("%.1f", currentLux));
        }
    }
}
```

Built-in light sensor has wide field of integration

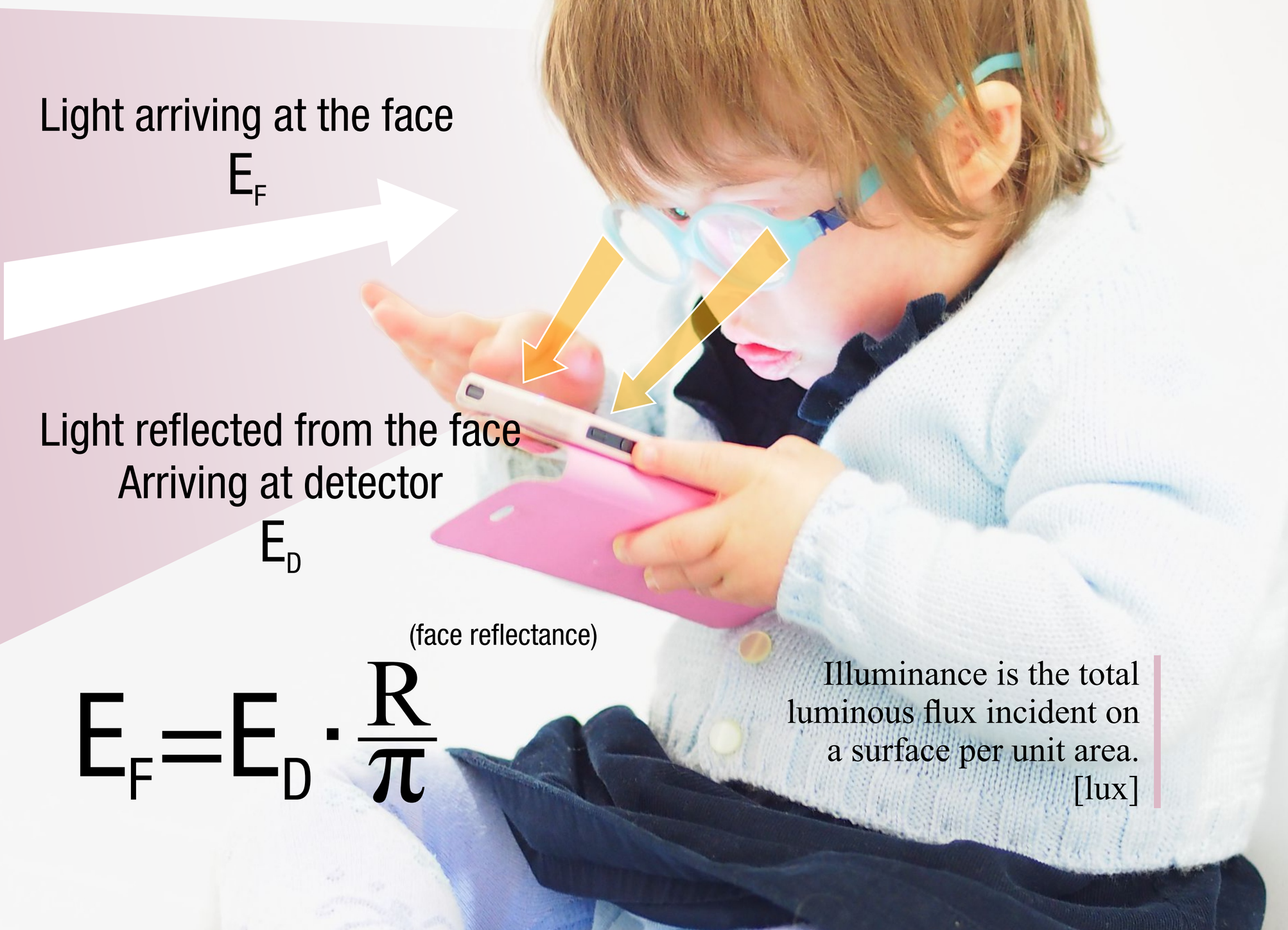
(much wider than face angle)





Light arriving at the face

E_F



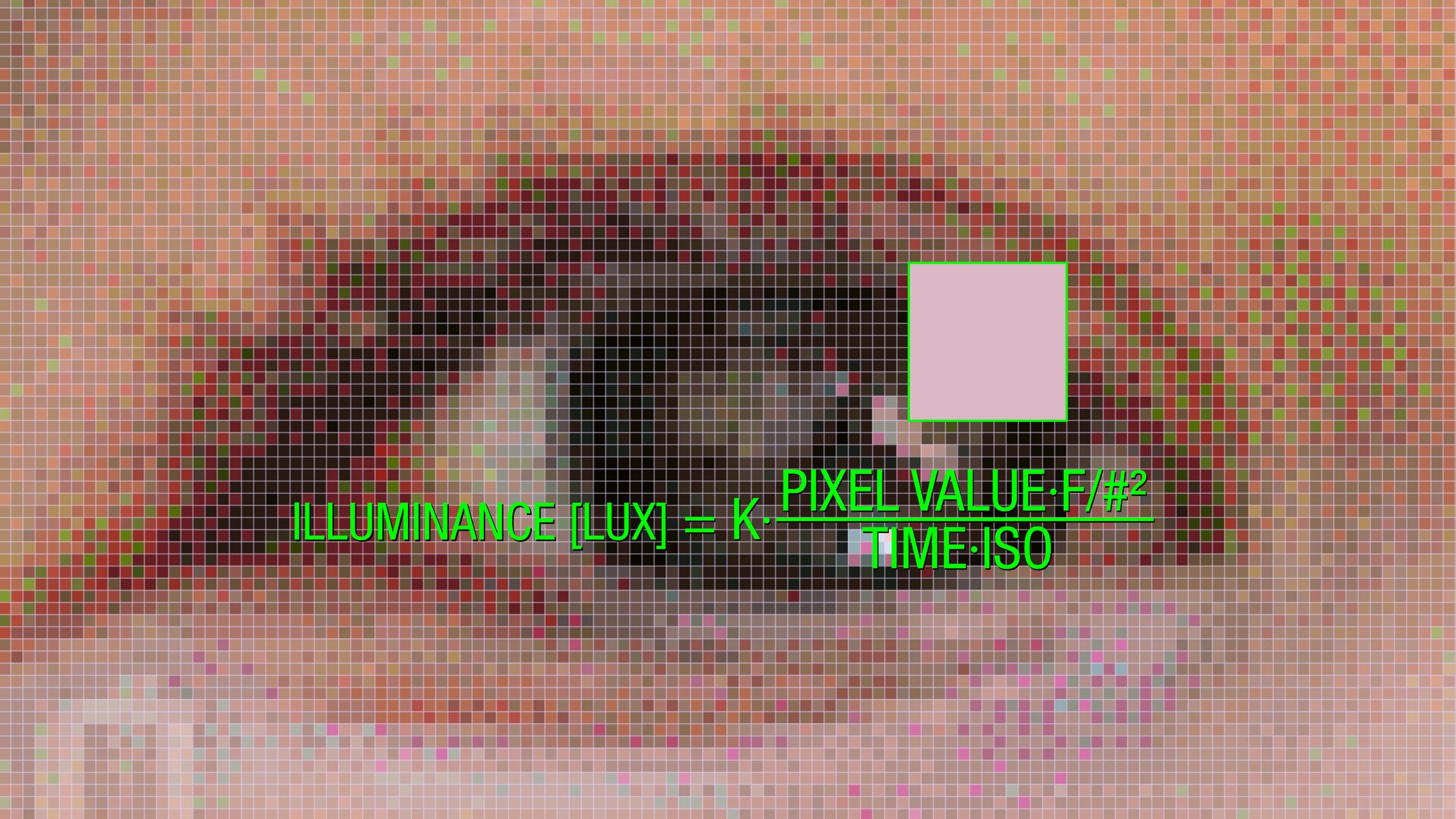
Light reflected from the face
Arriving at detector

E_D

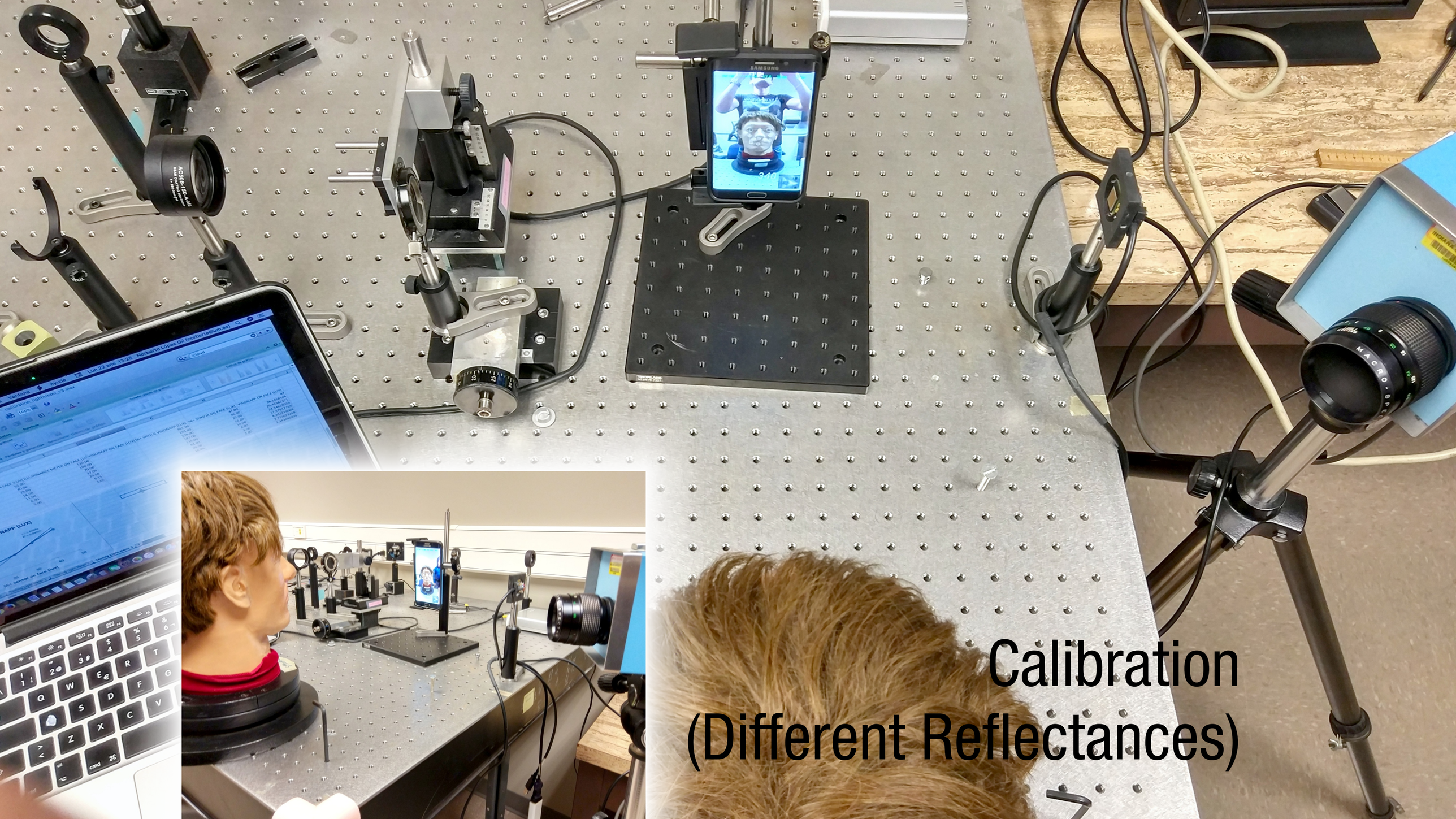
(face reflectance)

$$E_F = E_D \cdot \frac{R}{\pi}$$

Illuminance is the total luminous flux incident on a surface per unit area. [lux]


ILLUMINANCE [LUX] = K· PIXEL VALUE·F/#²
TIME·ISO

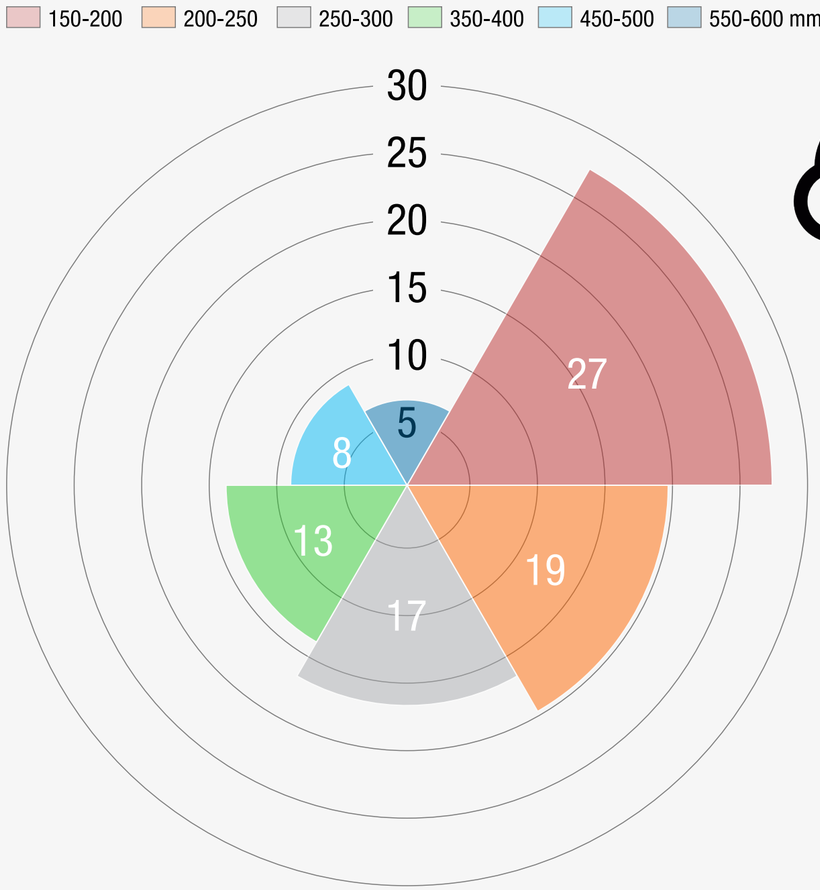
Calibration Office Scene


Calibration
(Different Reflectances)

Sync with Database (distance, time, face illuminance)

1 sample every 10 seconds (3600 per child every hour)

Time [min]
of near work at a distance [mm] of:



Time [min]
of near work at a light level [lux] of:


Thank you for your attention!