Visual Psychophysics and Phenomenology

Its possible relation to biology

Visual psychophysics

- Long history (19th C)
- Fechner, Helmholtz, James C Maxwell
- Early identification of the fundamental properties/characteristics

color

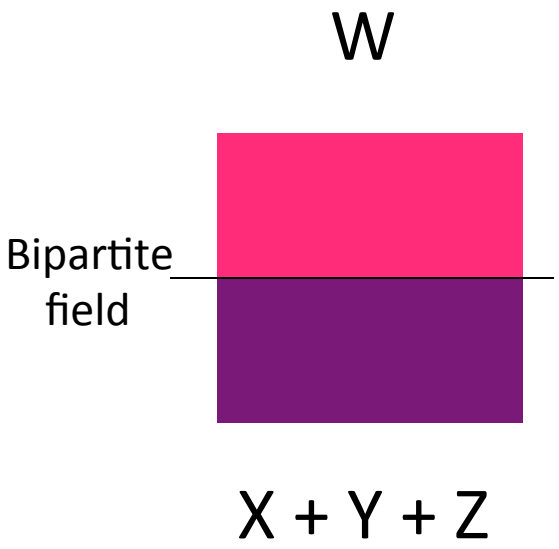
Young's Theory

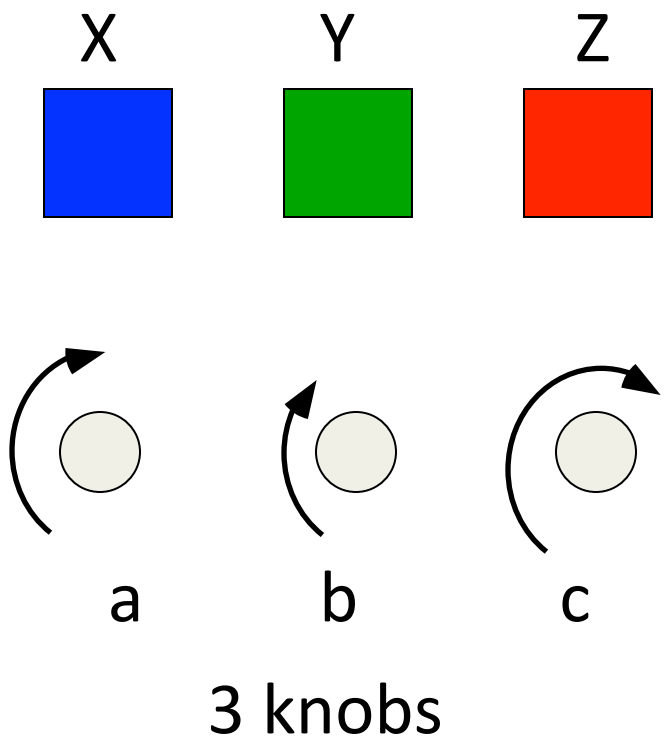
"As it is almost impossible to conceive each sensitive point of the retina to contain an infinite number of particles, each capable of vibrating in perfect unison with every possible undulation, it becomes necessary to suppose the number limited, for instance to the three principal colours, red, yellow and blue".

Thomas Young, 1802

19th C. color matching experiment

Key observation



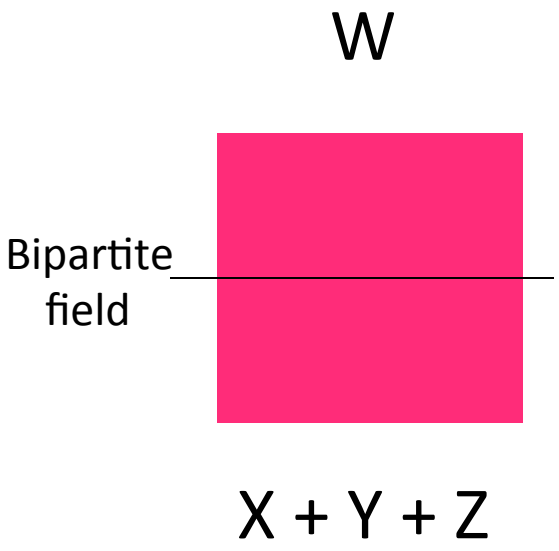


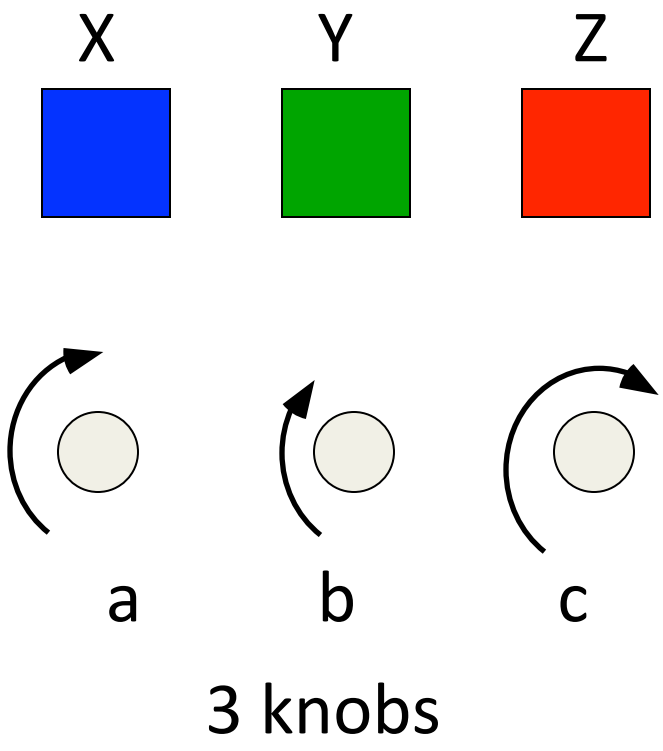
$$W \equiv aX + bY + cZ$$

color matching equation

19th C. color matching experiment

Key observation

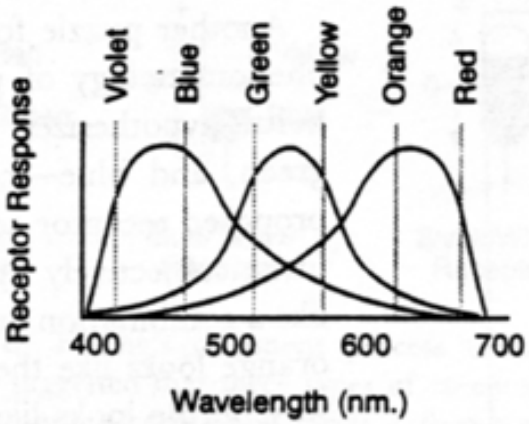


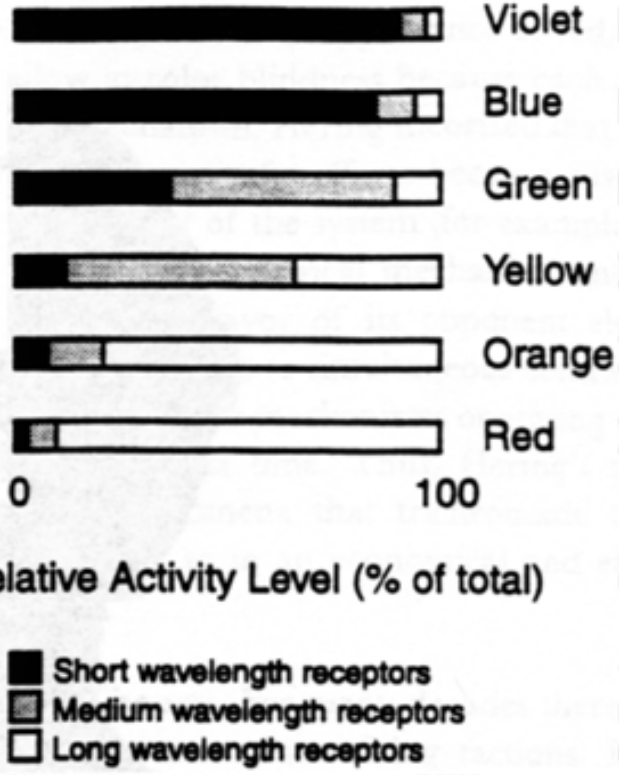


$$W \equiv aX + bY + cZ$$

color matching equation

- In 1852 Hermann Von Helmholtz suggested that only 3 receptors are needed for colour vision, each broadly tuned to wavelength (*trichromacy theory*).
- He suggested that perceived colour depends on the relative strength of their activations.





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Human visual pigments: microspectrophotometric results from the eyes of seven persons

BY H. J. A. DARTNALL[1], J. K. BOWMAKER[2] AND J. D. MOLLON[3]

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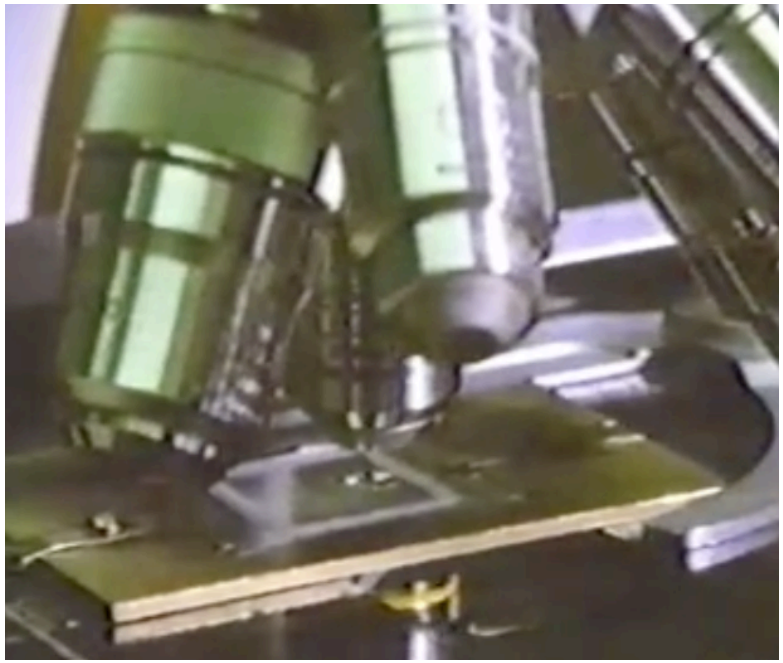
The material for this work was obtained from seven eyes removed because of malignant growths. Foveal and parafoveal samples of the retinas were taken and transverse measurements were made of the absorbance spectra of the outer segments of the rods and cones, using a Liebman microspectrophotometer.



Absorption spectra of
single human cone receptors

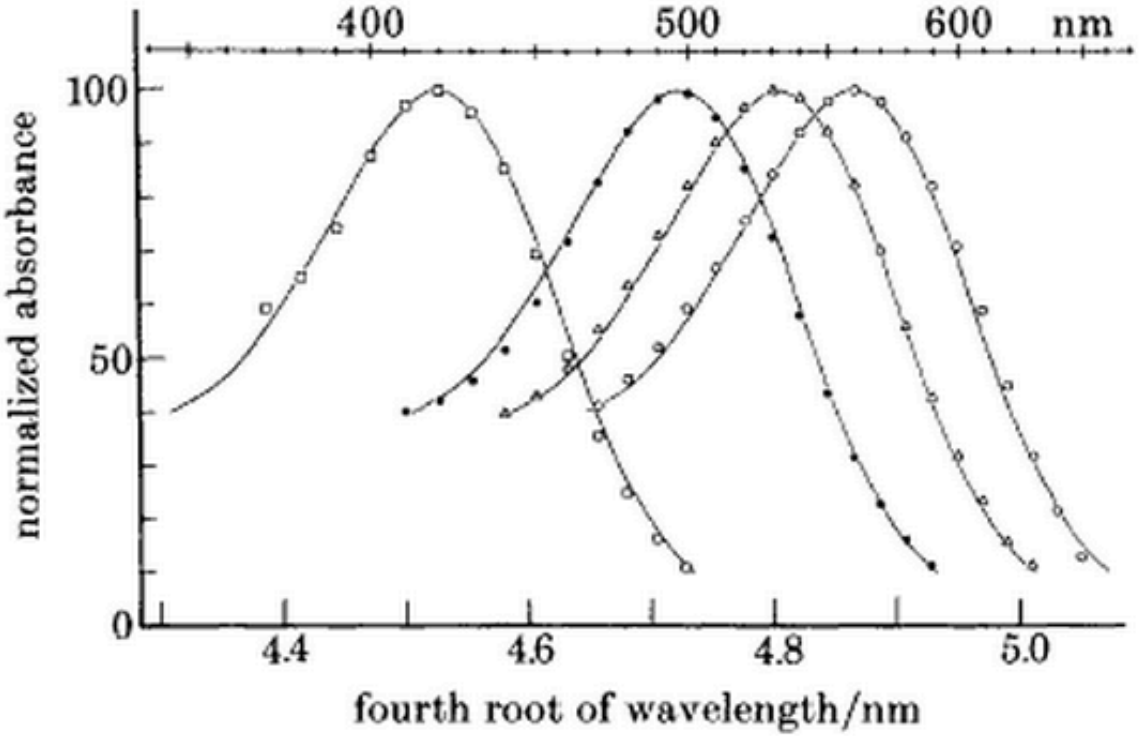
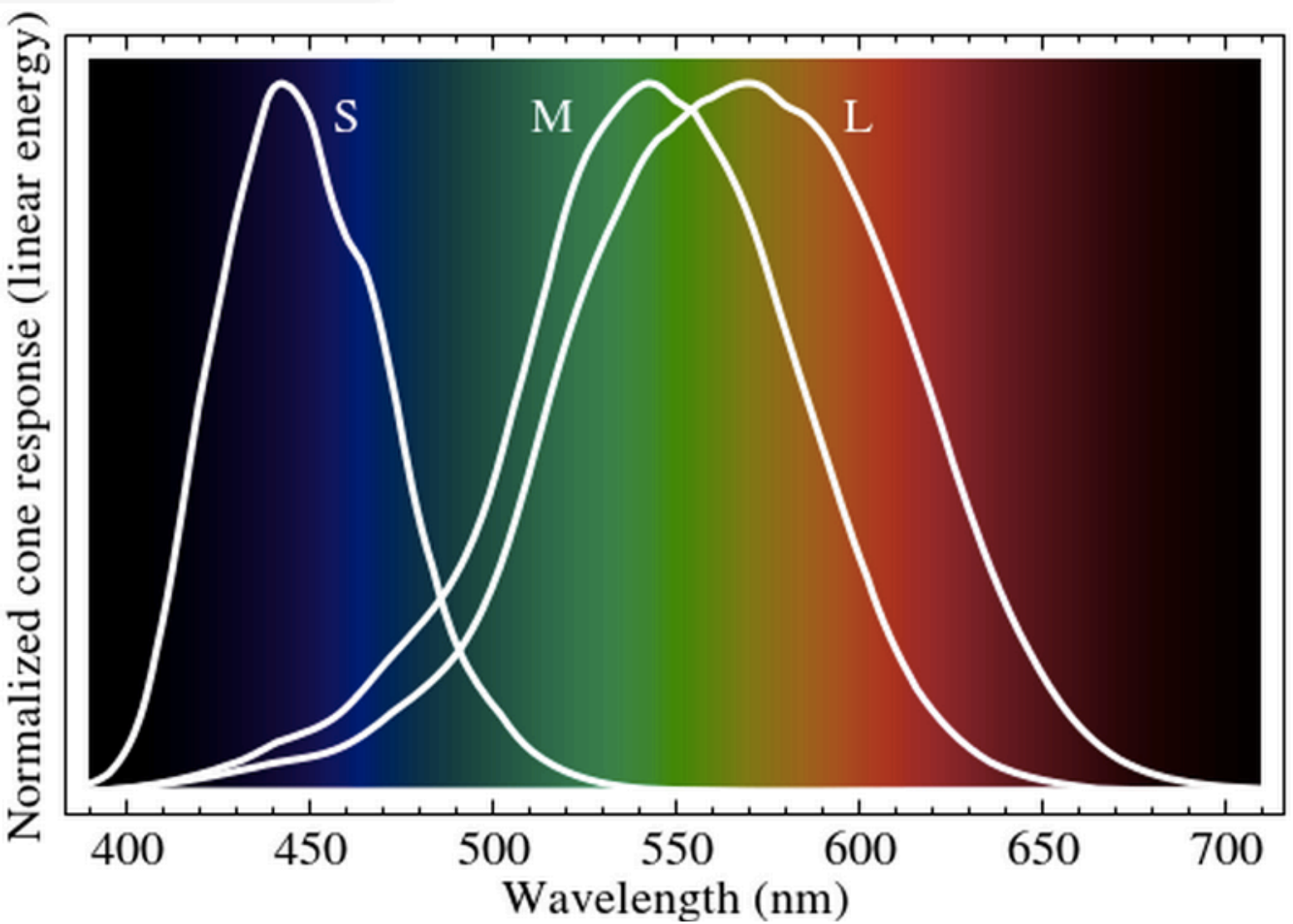
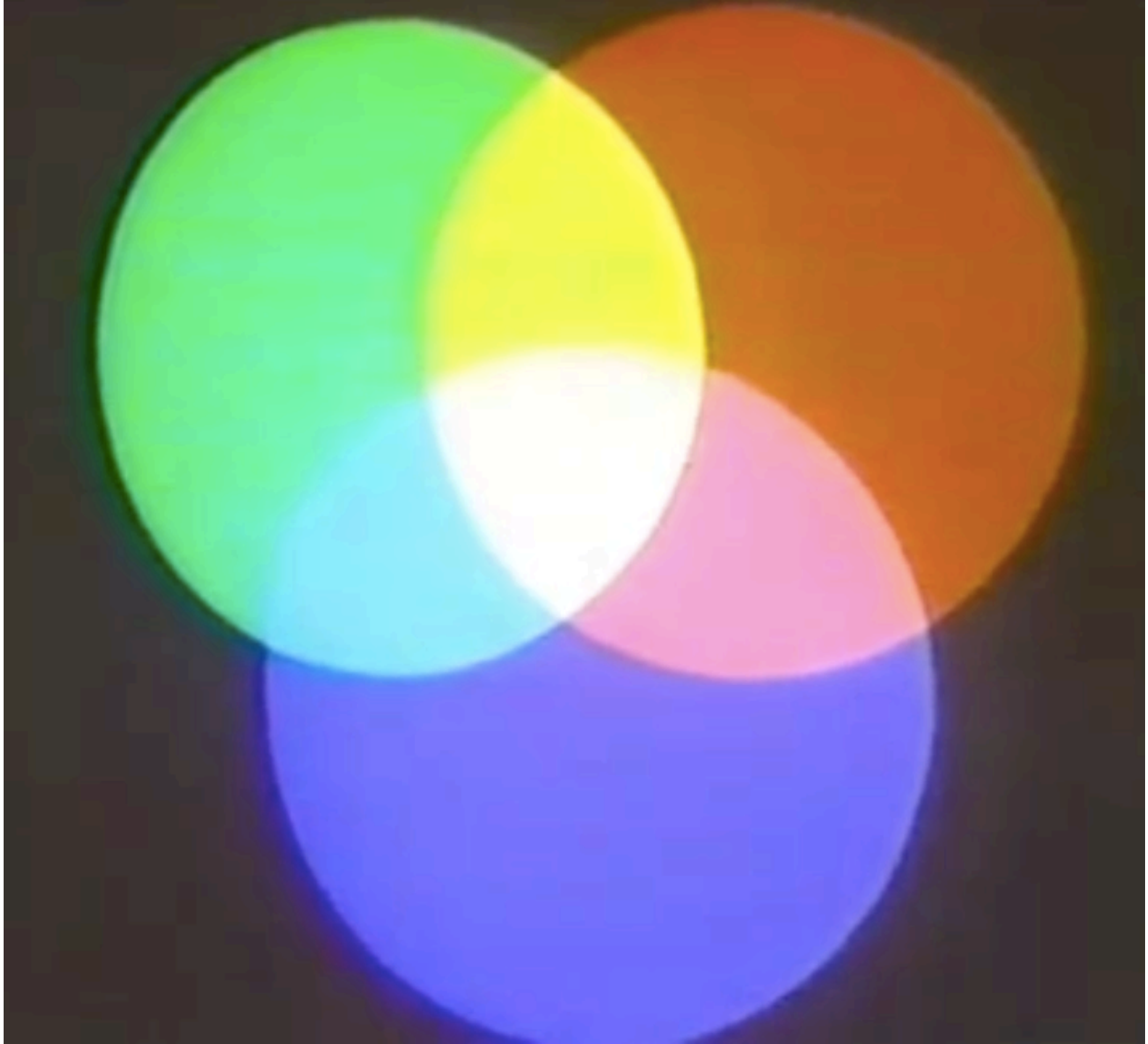
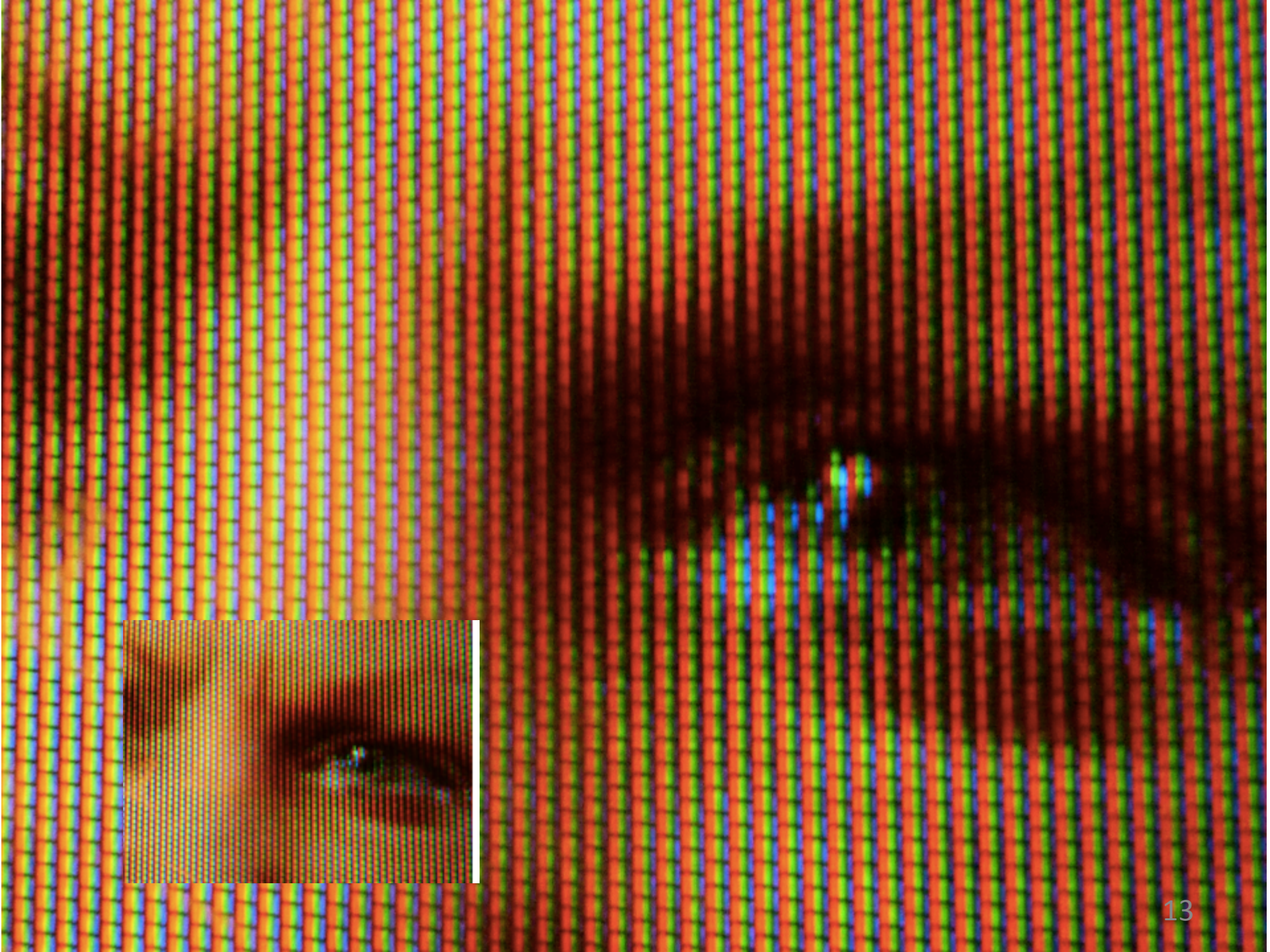


FIGURE 2. The mean absorbance spectra of the four human photoreceptors. Squares, the blue cones ($\lambda_{max} = 419.0 \pm 3.6$ nm, mean of 5); filled circles, the rods ($\lambda_{max} = 496.3 \pm 2.3$ nm, mean of 39); triangles, the green cones ($\lambda_{max} = 530.8 \pm 3.5$ nm, mean of 45); plain circles, the red cones ($\lambda_{max} = 558.4 \pm 5.2$ nm, mean of 58). The curves are all exactly the same shape and were constructed from the mean human data of table 4. Note inset scale of wavelengths.



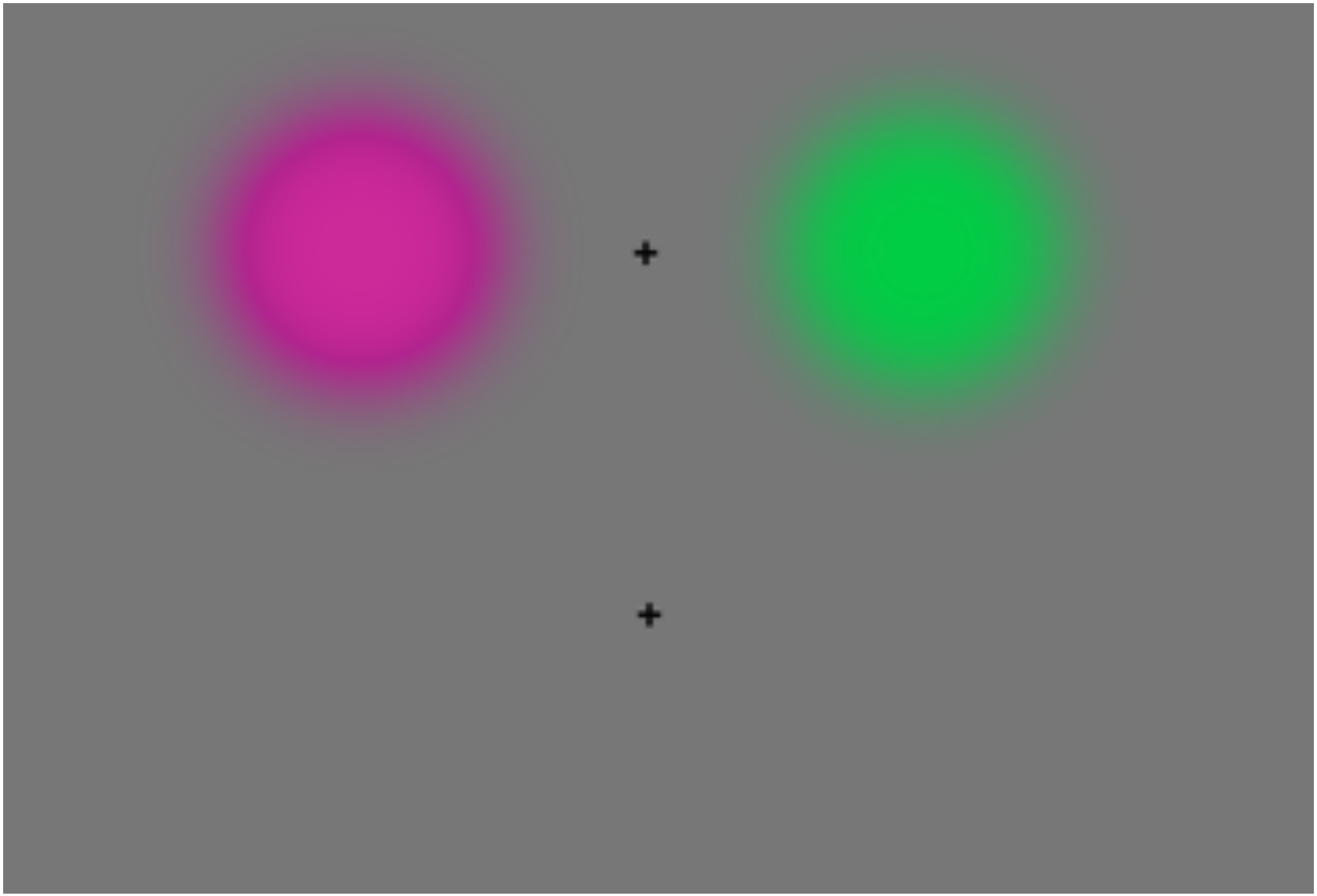
Individual cone sensitivies to wavelength

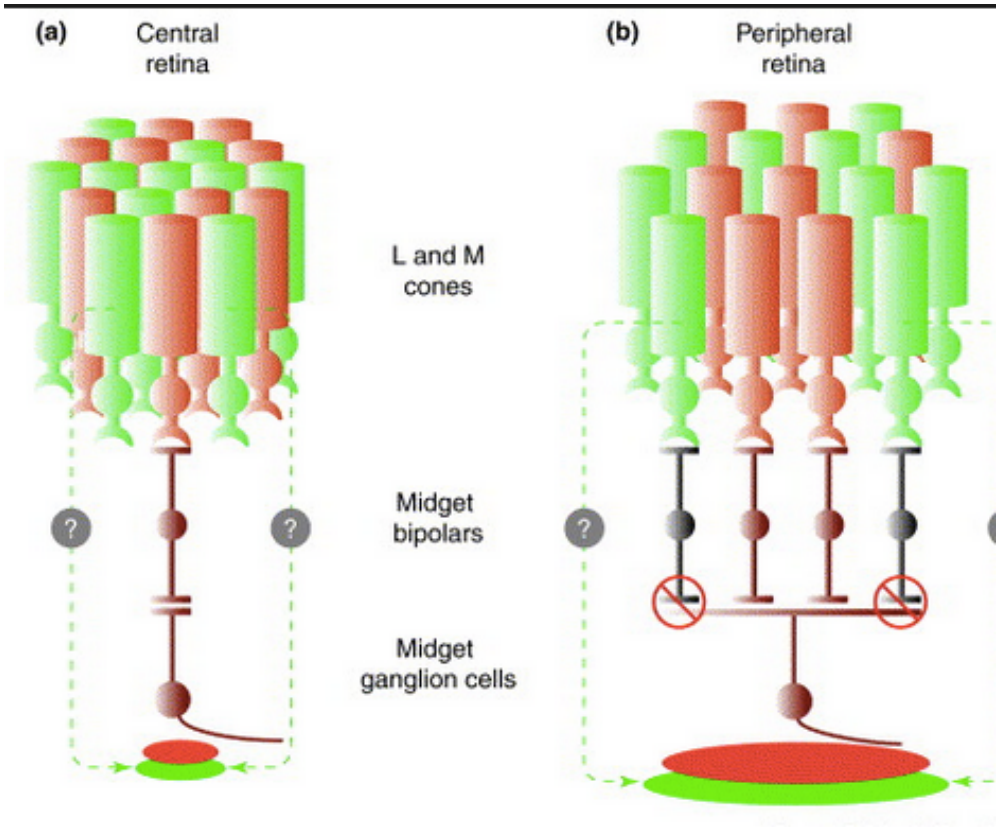




Neural adaptation
Ewald Hering
19th C

- Colors are arranged in an opponent relation





Red green opponency in Monkey retina

R+ G- R-G+

ENERGY, QUANTA, AND VISION*

BY SELIG HECHT, SIMON SHLAER, AND MAURICE HENRI PIRENNE‡

(*From the Laboratory of Biophysics, Columbia University, New York*)

(Received for publication, March 30, 1942)

I

Threshold Energies for Vision

The minimum energy required to produce a visual effect achieves its significance by virtue of the quantum nature of light. Like all radiation, light is emitted and absorbed in discrete units or quanta, whose energy content is equal to its frequency ν multiplied by Planck's constant h. At the threshold of vision these quanta are used for the photodecomposition of visual purple, and in conformity with Einstein's equivalence law each absorbed quantum transforms one molecule of visual purple (Dartnall, Goodeve, and Lythgoe, 1938). Since even the earliest measurements show that only a small number of

Visual psychophysics

one rod - one quanta

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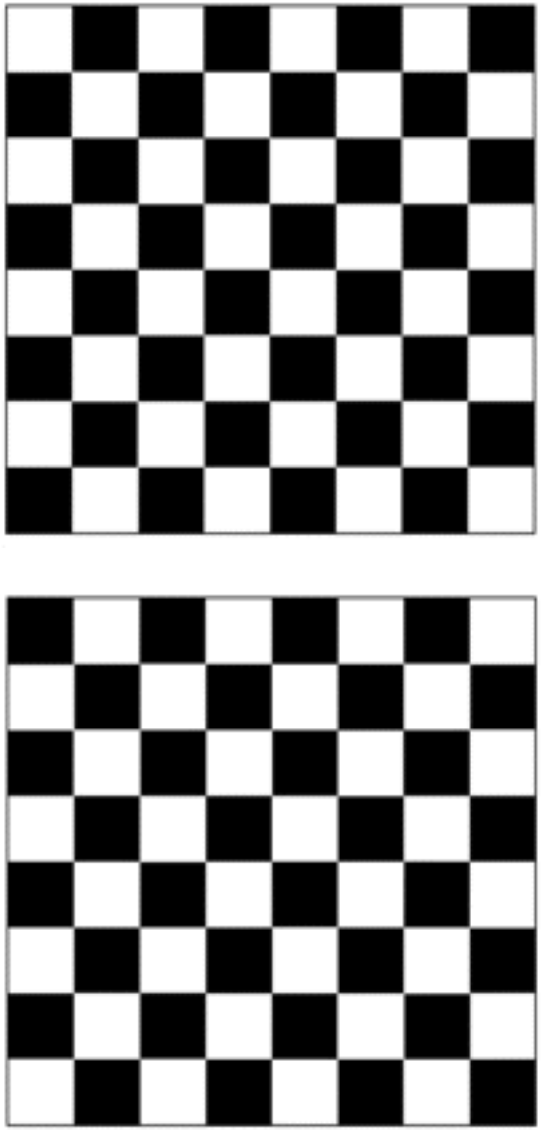
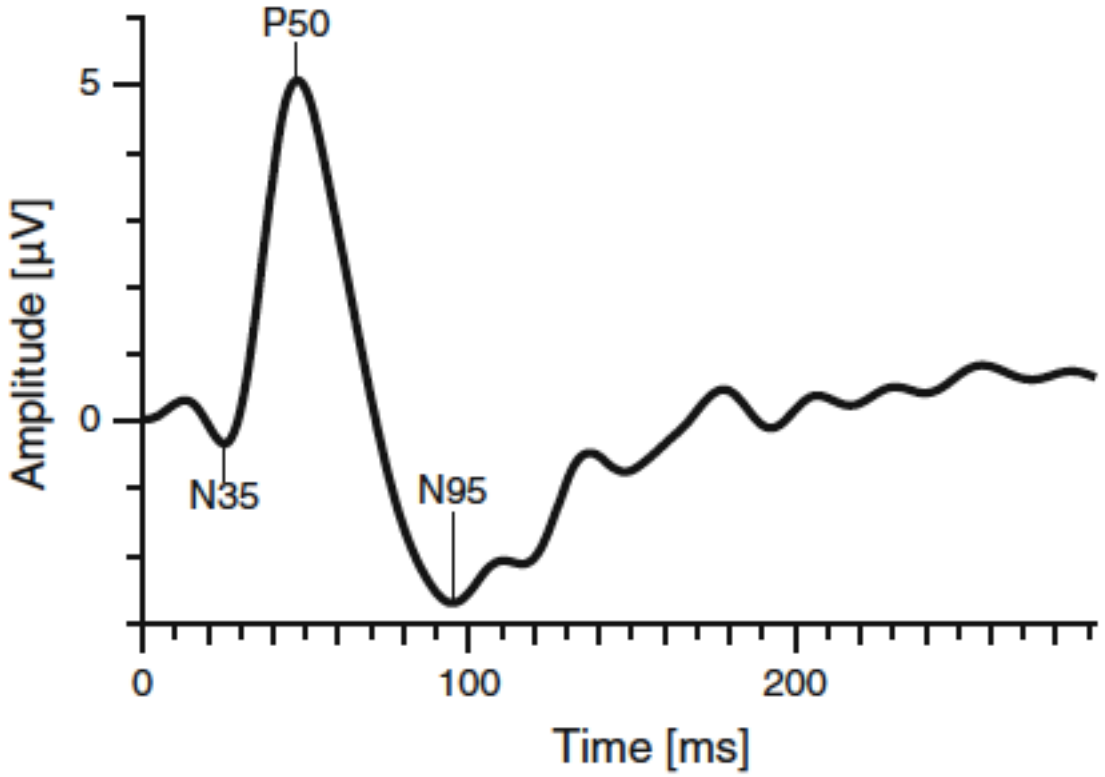
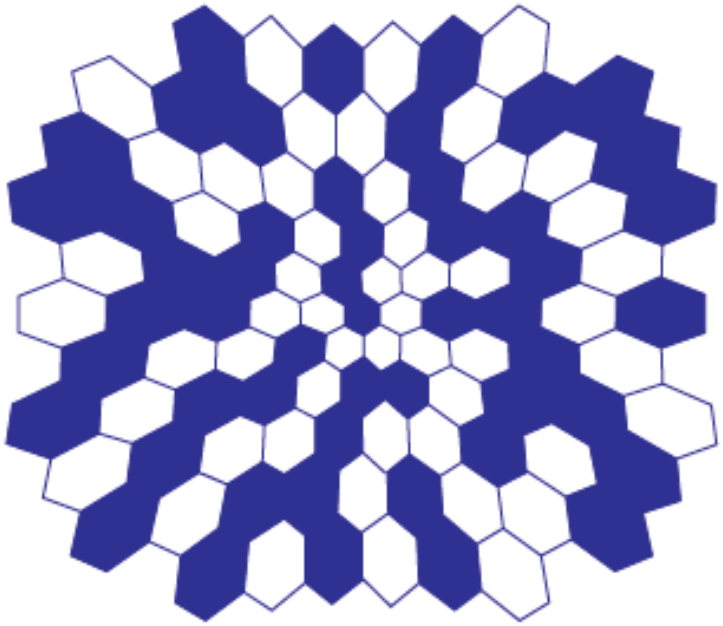
Pattern ERG

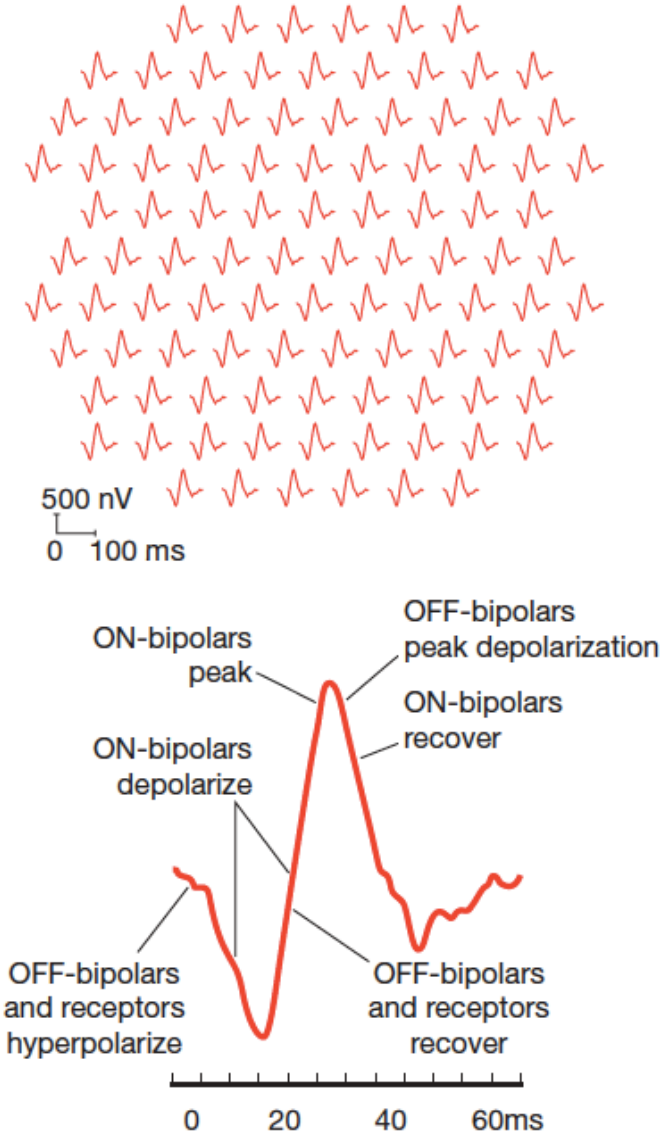




Multi-focal ERG

Invented by
Erich Sutter





Possible approaches

- psychophysics → ERG → cellular biomarker?

Example
3 studies of major depression

Vision in depressive disorder

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[1]*Department of Psychiatry and Psychotherapy, Albert-Ludwigs-Universität, Freiburg, Germany, and* [2]*Department of Experimental Psychology, University of Regensburg, Regensburg, Germany*

Abstract

Background. Reduced dopaminergic transmission has been implicated in the pathophysiology of major depression. Furthermore, dopaminergic neurotransmission plays an important role in the physiology of visual contrast sensitivity (CS). To test the hypothesis that altered dopaminergic neurotransmission plays a role in major depression we measured contrast sensitivity in patients with major depression and in healthy control subjects. *Methods.* Twenty-eight patients diagnosed with major depressive disorder were compared to 21 age-matched control subjects on their ability to detect a Gabor target with slightly elevated luminance contrast embedded in seven equi-contrast distracters. *Results.* Contrast discrimination thresholds were significantly elevated in unmedicated and medicated patients with major depression compared to control subjects, at all pedestal contrast levels tested. *Conclusions.* Contrast discrimination performance is reduced in depressive patients and might reflect a state of altered dopaminergic neurotransmission.

Reduced contrast sensitivity

Tested using psychophysics

Pattern electroretinogram in depression

Reduced pattern ERG