Biophysics of Color Vision

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This bachelor's thesis presents a complex biophysical analysis of the formation of human color vision and its deficiencies. Within the scope of this research, we are creating a computational simulation model to investigate how population variations of cone cells affect color discrimination thresholds (Just Noticeable Difference - JND) across the entire visible spectrum.

Key Findings:

- **Normal Trichromatic Vision:** The simulation demonstrates optimal color discrimination at a wavelength of 550 nm with minimal JND values of ~1.0-1.1 nm. This confirms the well-established fact that peak sensitivity is observed in the yellow-green spectral region, where the sensitivities of L and M cones have the greatest overlap.
- **Color Vision Deficiencies:** Protanopia and deuteranopia show severely impaired discrimination in the red-green spectral regions (520-650 nm), where JND values are increased by 8-fold compared to normal vision (22+ nm compared to 2.7 nm). This validates the functional impact of cone cell deficiencies.
- **Spectral Specificity:** Tritanopia exhibits a selective impairment in blue-yellow color discrimination (6.1 times worse than the control group), while partially retaining red-green color discrimination, though not to the extent predicted by theory.

Significance:

This study provides a means to quantitatively assess the relationship between photoreceptor physiology and color discrimination. It offers a validated computational tool for use in the fields of vision science and education.