

Glasses for the Color Dificient

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1 Introduction

EnChroma is a pair of glasses used to assist patients with color weakness. In the ads published, they claim that patients with color weakness can view the colorful world like ordinary people by wearing the glasses.

2 Effects of *EnChroma*

Suppose that an image is composed of three colors, whose RGB are [230, 100, 0], [230, 10, 0], and [10, 230, 0]. The percents of the three colors are 50%, 30%, 20%.

For a person with normal eyes, suppose that the sensitivity of red cone cells is 0.5 for red color and 0.3 for green color. The sensitivity of green cone cells is 0.2 for red color and 0.5 for green color. Then the spectral response for red cone cells is $230 * 0.5 * 0.5 + 100 * 0.5 * 0.3 + 230 * 0.3 * 0.5 + 10 * 0.3 * 0.3 + 10 * 0.2 * 0.5 + 230 * 0.2 * 0.3 = 122.7$. The spectral response for red cone cells is $230 * 0.5 * 0.2 + 100 * 0.5 * 0.5 + 230 * 0.3 * 0.2 + 10 * 0.3 * 0.5 + 10 * 0.2 * 0.2 + 230 * 0.2 * 0.5 = 86.7$. The difference is 36.0.

For a person with protanope anomalous trichromacy, suppose that the sensitivity of red cone cells is 0.45 for red color and 0.3 for green color. The sensitivity of green cone cells is the same. Then the spectral response for red cone cells is $230 * 0.5 * 0.45 + 100 * 0.5 * 0.3 + 230 * 0.3 * 0.45 + 10 * 0.3 * 0.3 + 10 * 0.2 * 0.45 + 230 * 0.2 * 0.3 = 113.4$. The spectral response for red cone cells is still 86.7. The difference is 26.7.

For a person with protanope anomalous trichromacy who wears the glasses, suppose that the sensitivity of cone cells is the same. But the percents of three colors are converted to 5%, 70%, 25%. Then the spectral response for red cone cells is $230 * 0.05 * 0.45 + 100 * 0.05 * 0.3 + 230 * 0.7 * 0.45 + 10 * 0.7 * 0.3 + 10 * 0.25 * 0.45 + 230 * 0.25 * 0.3 = 99.6$. The spectral response for red cone cells is $230 * 0.05 * 0.2 + 100 * 0.05 * 0.5 + 230 * 0.7 * 0.2 + 10 * 0.7 * 0.5 + 10 * 0.25 * 0.2 + 230 * 0.25 * 0.5 = 69.75$. The difference is 29.85.

This calculation shows in principle that the glasses can help patients with color weakness to distinguish objects of different colors. The principle is to filter out the intermediate color, to make the red reder and green greener.

3 Simulation

The simulation idea is to reduce the value of a color component in the whole image.

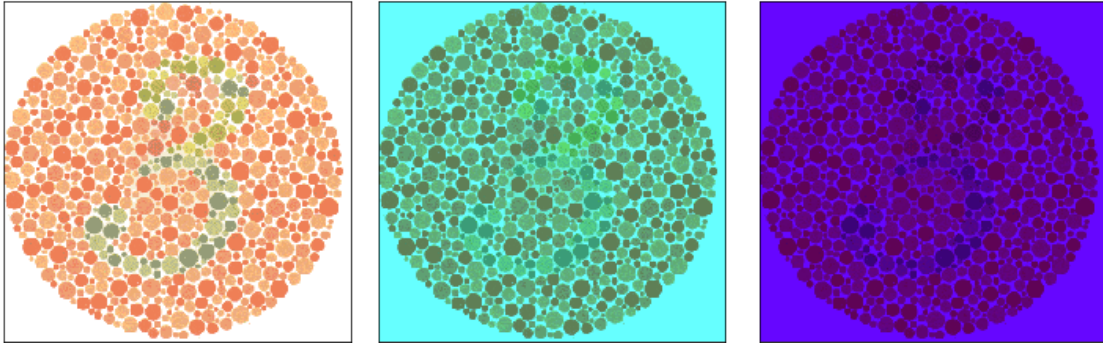


Figure 1: images viewed by a normal person, a patient, a patient after wearing the glasses

4 Potential Problems

- The glasses work by filtering out some light. It means that **what he sees is not the real color** and some details may be lost, although it is better than completely failing to distinguish colors. Besides, the intensity will weaken, which means that the glasses is not suitable for dark environment.
- After a pair of glasses is made, the light that can be filtered out is determined. In fact, the situation of each patient is different, which means that **the glasses will have different effects when worn by different patients.**

I think that the glasses do help a patient distinguish red and green objects, but what he sees is still different from what people with normal eyes see.