The Color Changing Dress

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1 Introduction

Many may have asked themself if everybody reckognizes the world like all the others. Or more specifically: Does everybody reckognize the colors like everybody else. This means: Does everybody see red like the other? Or does one see red like others see blue - or any other color?

The answer can be decided and it is - at least partly - no. The reason is the photo of a dress that occured this year (2015) in the internet [1] and caused confusion and violent arguments:

Figure 1: "The Dress"

Some see a white dress with golden stripes, other see a blue dress with black stripes. In the authors family two see it this way and two the other way. (The author, by the way, does see it in blue and black.)

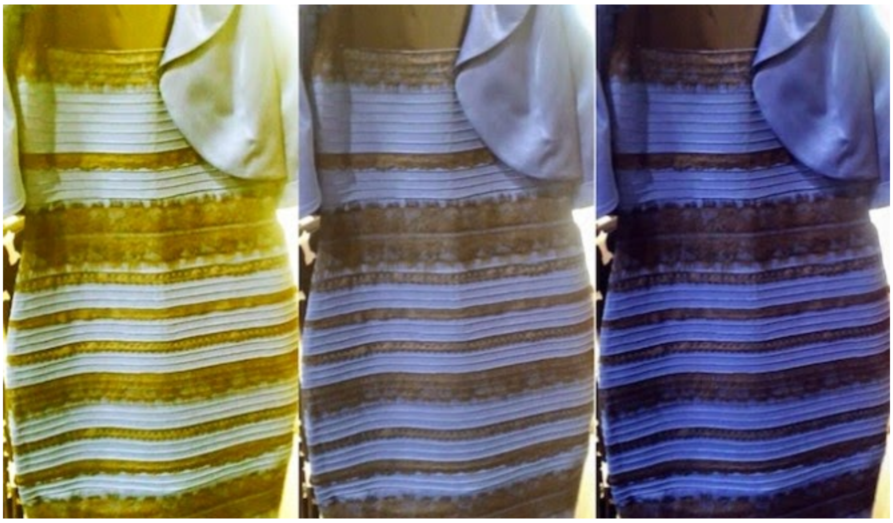

Figure 2: Different views of 'The Dress'

The question is: How comes?

2 Testing Hypothesies

There are immediately two hypothesies coming to mind:

1. The color depends on the format of the photo.
2. The color depends on the physiology of the human eye.

While testing the first one is easy, the second needs more facts and figuring.

2.1 Does The Color Depend on the Format of the Photo?

The original photo is a JPG-format. Even while this format uses color compression it offers 16 million colors. Reducing the image to GIF-format reduces the colors to 256 and also uses dithering of the colors:

Figure 3: The Dress: Original JPG-format

Figure 4: The Dress: Reduced GIF-format

The effect to the perception does not change, although the pixel colors changed. The following are same increased samples of the pixel patterns of the original and processed photos:

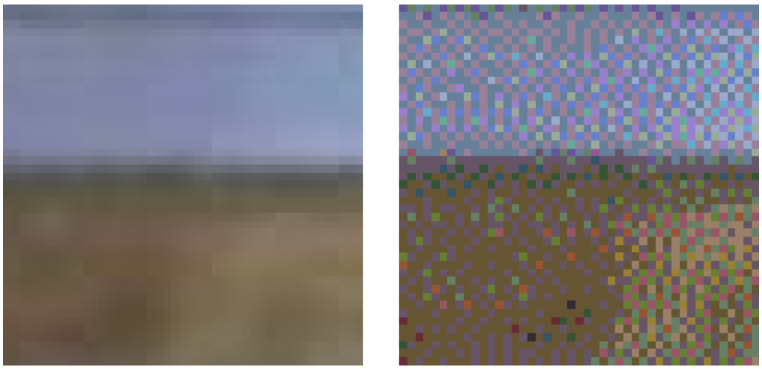

Figure 5: Pixel patterns: JPG (left) and GIF (right)

(Here the effect might vanish due to the size of the pixels.)

The **conclusion** is that the effect does not depend on the physical properties of the photos but on the perception by the human eye and its sensing properties.

2.2 Does The Color Depend on the Physiology of the Human Eye?

Colors are no feature of the physical world, because the electromagnetic waves form a continuous spectrum. Color vision is a biological interpretation of the intensity of three intervals in the visible part of the electromagnetic spectrum. Waves with greater wavelength are seen as red, waves with shorter wavelength are seen as blue, and wavelengths in between are interpreted as green (RGB model).

2.2.1 RGB Color Model

Combinations of different intensities of the three colors allow to see the whole color spectrum like in the RGB model of computer generated colors: For Example, Black is (RGB) = (000, 000, 000), White is (RGB) = (255, 255,255), Medium Gray is (RGB) = (127, 127, 127), Yellow is (RGB) = (255, 255, 000) and so forth.

First the colors for an "Idealized Dress" were picked:
The bright stripes have the color (RGB) = (190, 190, 210)
The dark stripes have the color (RGB) = (110, 100, 50)

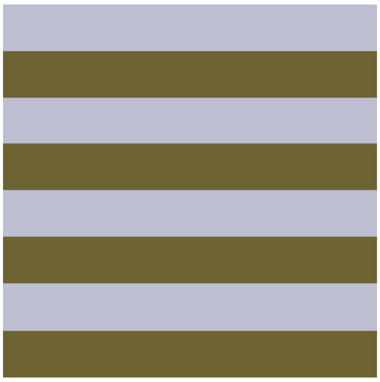

Figure 6: Optimal idealized dress

This color model suggests that the sensing of the intensity is equal for all three color sensors of the retina.

Some graphics for normalized absorbance suggest this too [2] ...

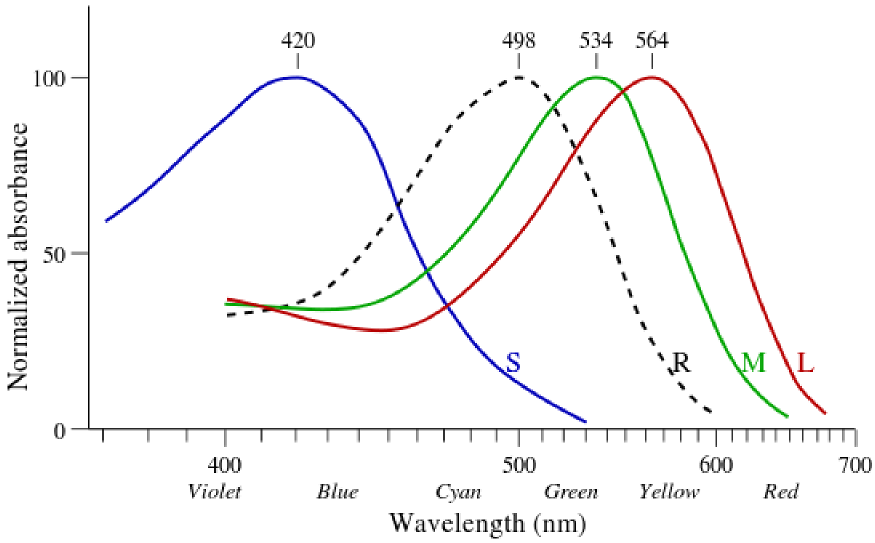

Figure 7: Normalized absorbance

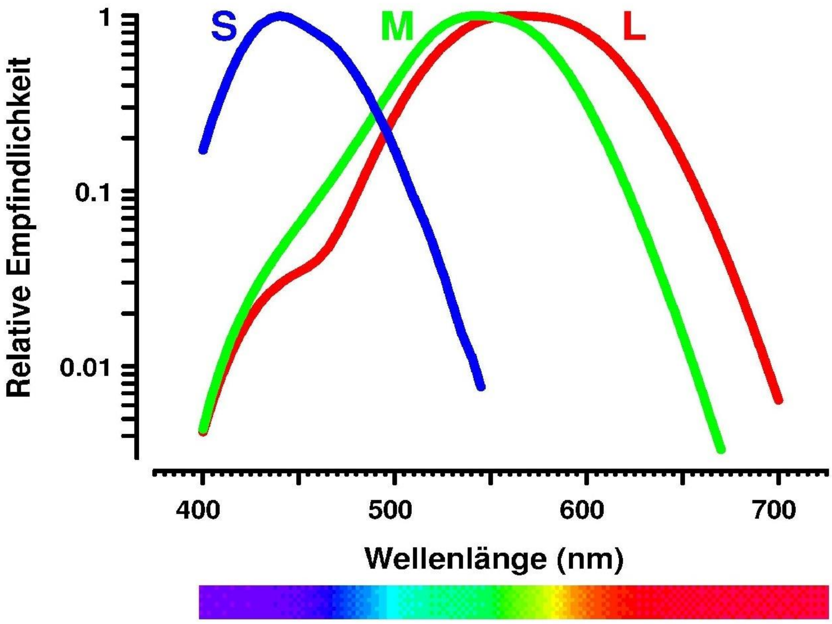

Figure 8: Relative) sensitivity

... but other graphics for absolute absorbance show different intensity levels.

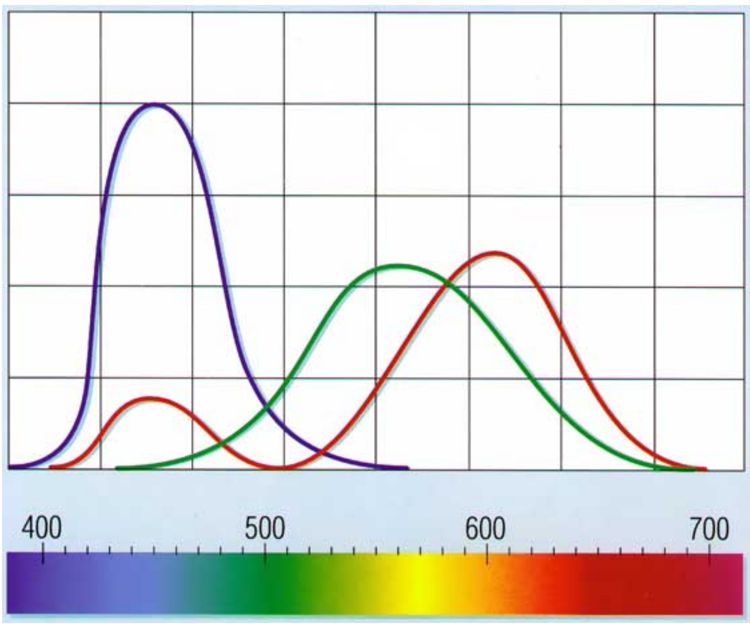

Figure 9: Absolute sensitivity, example 1

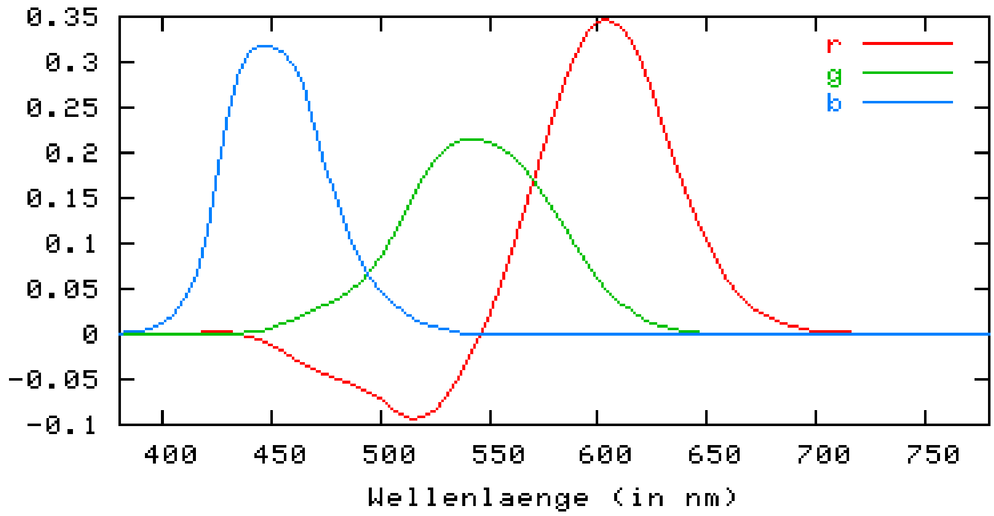

Figure 10: Absolute sensitivity, example 2

However, the graphs are not very consistent.

2.2.2 Color Sensing

The question is, if differences in the intensity sensing in different sets of humans may cause the different color vision of "The Dress".

The green sensor is together with the blue sensor biologically older, and the red sensor is an offspring of the green sensor. Therefore, the idea is that the sensing of intensity in the red and green sensor is weaker in people who see the dress in black and blue than in people who see it white and yellow.

To test this idea, first, an idealized dress with two colors was created.

In this case the chosen colors are
Bright stripe: (RGB) = (170, 170, 204)
Dark stripe: (RGB) = (85, 85, 50)

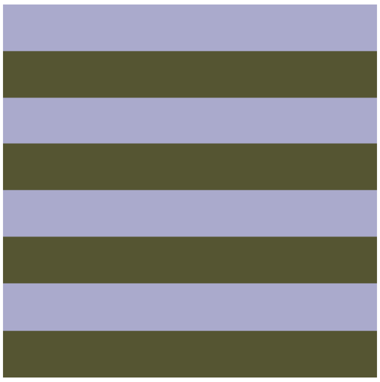

Figure 11: Idealized dress

An interesting thing is that these two colors are complement to each other, their color distance to the medium gray (127) is of the same size, only in different directions:

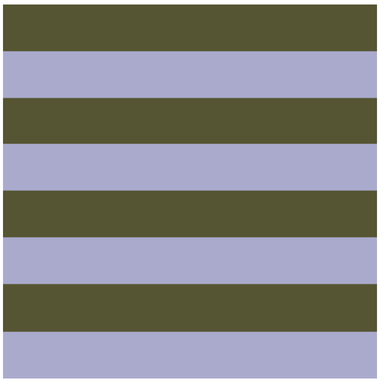

Figure 12: Idealized dress with complement colors

People seeing these colors as black and blue may have a weakness in the perception of red and green compared with blue. To simulate this decreased intensity sensing of the two colors and to make the effect visibible for everybody, red and green is reduced by 50% in the following picture:

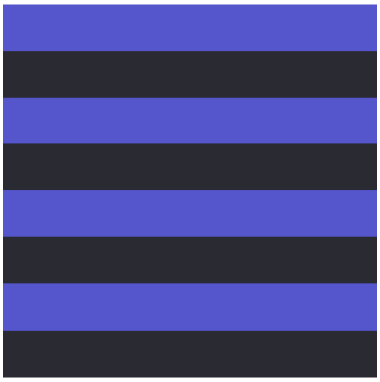

Figure 13: Colors with reduced red-green intensity

The colors turn to blue and black:
Bright stripe: (RGB) = (85, 85, 204)
Dark stripe: (RGB) = (42, 42, 50)

People who see the dress in white and gold may have an equal perception for all three colors or even an enhanced intensity perception for red and green. To simulate this and make the effect also visible for everybody, red and green is enhanced 50% in their intensity:

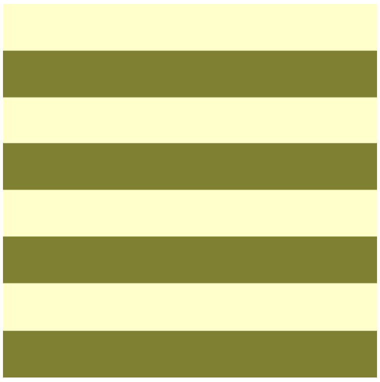

Figure 14: Colors with increased red-green intensity

Now the colors look more white and gold:
Bright stripe: (RGB) = (255, 255, 204)
Dark stripe: (RGB) = (128, 128, 50)

What looks brownish here may look golden if sprinkles of other collors like red, yellow, geen, or darker browns are added:

Figure 15: Gold: Above the original color stripe, below the same stripe with red and green lightened up

3 Conclusions

This simulation may explain why the colors of this dress are so differently percieved.

The effect does not depend on the physical properties of the photos but on the perception by the human eye and its sensing properties.

The reason is the different intensity sensing of the red-green-sensors in the human eye. Here the properties of this two biologically related sensors were the cause for the different sensing. It would be interesting, if other combinations of intensity perception could be found. E.g. in the blue and the red sensing while the green sensing remains the same.

Finally, at least in the family of the author, the people who see "The Dress" in white and gold are very sensitive to bright light. After all, with the increased intensity sensitivity of the red and green sensors the overall intensity sensing seems increased, so the result seems plausible.

Figure 16: "The Dress" re-designed in real white and gold

4 Sources

References

[1] Internet:
Google Search: the dress
2015

[2] Internet:
Google Search: eye color sensitivity
2015