Effects of using RGB screens to alter color perception

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Abstract

This study explores the subjective experience of color perception using color arrangement tests. Many color arrangement tests on electronic screens use red, green, blue (RGB) displays. Since the visuals created by a screen are the combination of three colors, this study examined if the light emitted from them produces a different perception than that of natural light. This was accomplished by changing the overall screen display and seeing if the perception of the user will be altered, if at all.

Introduction

Color perception is a major evolutionary advantage that humans use to navigate everyday life. Color is used to indicate semantic meaning in things such as stoplights and warning labels. It also has aesthetic meaning, websites explicitly design specific color palettes to incite specific emotions. For example, blue with comfort and security and red with alertness or anxiety [1].

However, is the color we see on our screens truly the same as what we might experience in the real world? This study examines the effects of modifying the color displayed to the user, and how that might change their perception. Specifically, blue light was removed from the display and a color arrangement test was done to measure any differences compared to normal light. I hypothesize that removing blue light will induce a perception similar to that of Tritanopes, who lack working S cones [2].

From this, if a different perception of color can be induced, then it might be inferred that RGB screens effectively fool the brain into perceiving colors like natural light. Inducing different color perception can also allow us to discover if an individual might have a color deficiency. If we can induce a different perception of color, then those who already have some form of color blindness should have very different results than those with normal color vision. A potential application of this would be to introduce an electronic test to examine color deficiency. This could be helpful as an inexpensive test deployed into schools that can be tested on children to identify color deficiencies early on.

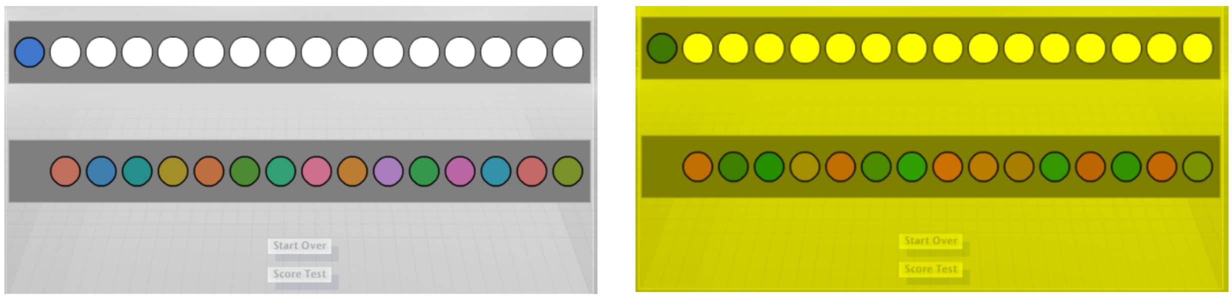
Methods

10 subjects took a color arrangement test under normal visual conditions and 10 subjects took the same test in the absence of blue light. Their performance was then measured and recorded after completing the test. The color arrangement test consisted of 15 colors the subject had to place in an order such that a gradient formed from blue to purple. The first color, blue, was placed at the far left. Subjects would have to drag and drop the colors from

[1] *Valdez, Mehrabian*, Effects of Color on Emotions *1994* ,
https://pdfs.semanticscholar.org/4711/624c0f72d8c85ea6813b8ec5e8abeedfb616.pdf

[2] *Dr. Jackie Berry*, Perception Chapter 9 Final1 *2019*

the bottom drawer to the upper to create the gradient in the Virtual lab environment. No subject in either group claimed to have any type of color blindness. Blue light was removed from the screen using the program, f.lux [3].



(a) Normal conditions (b) Blue light removed

Figure 1: Virtual Lab interface

Figure 2: Complete, correct ordering

Results

This study and the Virtual lab use the scoring technique developed by Vingrys and King-Smith [4]. The order in which the colors were placed down will allow the measurement of their perception of the color spectrum. The average placement of every color was taken for comparison. Group one's ordering matched the expected perfect ordering closely. There were a few minor mistakes in certain trials but nothing to imply that anyone in the group had a form of color blindness. Group two's ordering was not as close a match to a Tritanope's expected ordering, but does have a nontrivial resemblance.

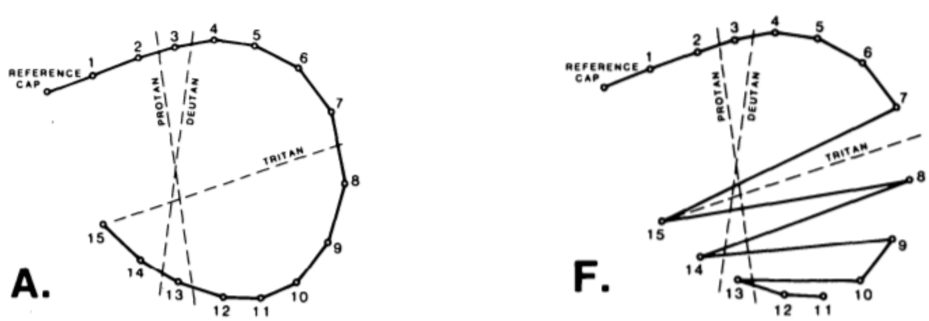


Figure 3: A: expected normal vision ordering, F: expected Tritanope ordering[4]

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[3] f.lux, https://justgetflux.com/

[4] *Vingrys, Even-Smith*, A quantitative scoring technique for panel tests of color vision *1988* https://www.ncbi.nlm.nih.gov/pubmed/3257208

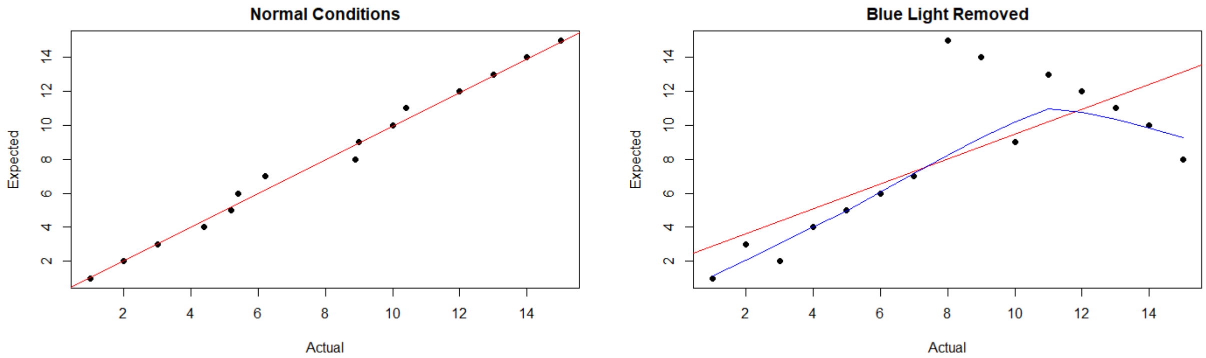

Figure 4: Expected vs Actual results from group1 (left) and group2 (right)

When removing all blue light, part of the order matched the expected for a Tritanope, but there was a specific deviation in the order of colors 8-15. This area, under normal vision, would look like the transition between green to orange. However, if there were any region to be mistaken by a Tritanope, it would be this area as all the colors within this range would look gray. One explanation could be the selection of colors used, a larger gradient that would be composed of over 15 distinct colors may produce better results.

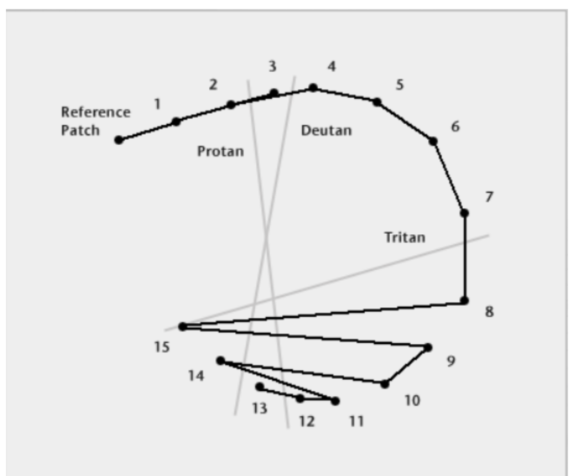

Figure 5: An example subject's ordering, note the similarities to Figure 3F on the previous page.

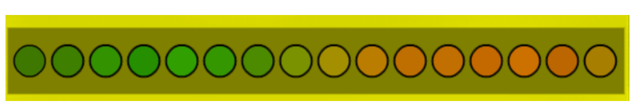

Figure 6: The correct ordering in the absence of blue light.

Subjects in group two reported not being able to tell many of the colors apart, and changed their orderings multiple times. Although the time to complete the test was not measured, group two took a noticeably longer time to complete. Multiple subjects reported that the test 'hurt their eyes' and was very difficult.

Discussion

From these results, it can be concluded that the absence of blue light in an electronic screen induces a perception similar to that of Tritanopia, but not exactly like it. Although there exists a variation in the ordering, it appears that many of the subjects in group two shifted their ordering by one, starting from color eight. A possible explanation of this could be that the remaining wavelengths of light, red and green, combine to activate specific rods in the eye. Whereas in natural light, there would be less rod activity and the perception would be closer to a dim gray [5].

Regardless, there is a noticeable, consistent change in order when blue light is removed. If an individual with Tritanopia were to perform the task under normal conditions, their expected ordering would be close but not exactly like our results under simulated conditions. From this, electronic measures of color vision may have potential issues to their accuracy but can most likely find when there is a significant difference in color perception.

Blue light was selected to be removed as many electronic displays emit a larger amount of blue light [6]. Future studies may experiment with removing red and green light to simulate the effects of Protanopia and Deuteranopia [7]. Although it is unlikely any subject in group two would have a form of color blindness, it was not explicitly tested for by running the color arrangement test normally on them. From the data there is no indication of anyone in group two having color blindness either, however in future studies, both versions of the test could be run to eliminate this possibility. This was explicitly chosen against in this study to prevent subjects from memorizing the location of the colors in the experiment setup.

Overall, color perception has a major impact on everyday life. Understanding the effects of this perception and what contributes towards it has overreaching applications across the design and development of everything we visually interact with.

Raw Data

Group one average ordering (1, 2, 3, 4.4, 5.2, 5.4, 6.2, 8.9, 9, 10, 10.4, 12, 13, 14, 15)
Expected ordering for normal (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)
Group two average ordering (1, 3, 2, 4, 5, 6, 7, 8, 15, 9, 10, 14, 11, 12, 13)
Expected ordering for Tritanopia (1,2,3,4,5,6,7,15,8,14,9,10,13,12,11)

[5] Jay Neitz and Maureen Neitz, The genetics of normal and defective color vision, *2010*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3075382/

[6] Harvard Health Publishing, blue light has a dark side, *2012*, https://www.health.harvard.edu/staying-healthy/blue-light-has-a-dark-side

[7] *Note:* the author could not figure out how to turn red or green light off, another major reason blue was selected instead