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Initial findings on changing the background in pseudo-isochromatic charts

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Abstract

This paper examines the effect of changing the background levels on pseudo-isochromatic charts.

Introduction:

Color vision deficiency is a common affliction for males, impacting about 8% of the population. The effects of this – colloquial – color blindness is the inability or limited ability to distinguish colors. A typical problem might be that a color changing LED, changing between red and green to indicate two states, will not be differentiated.

There are multiple ways to detect and distinguish color deficient people, ranging from genetic testing, to simple pseudo-isochromatic charts, as exemplified by the likely most known Ishihara charts, to elaborate color matching and color sorting tests, as exemplified by the Farnsworth-Munsell 100 Hue test.

In this presentation describe initial experimental data on changing the background color – or the color "in between the dots" - for a pseudo-isochromatic chart color deficiency test. For the experiment, we augment the white background with 4 different neutral gray-level values and measured the performance of known color deficient observers on these charts as a function of the new background.

Though preliminary, the data show a significant difference in the performance of color deficient observers, despite the main pseudo-isochromatic colors staying the same.

Pseudo-isochromatic charts

Color deficiency is conveniently described in the x,y-chromaticity diagram. A color deficient observer will exhibit one of the visual sensors to be either under-performing or missing completely. In the chromaticity diagram, the locations corresponding to the human visual "sensors" define so-called co-puncts. With each line running through a co-punct crossing the x,y-diagram in a way that colors along that line are not distinguishable (or difficult to distinguish) by a color deficient observer.

This is shown in Figure 1 where we are using the co-punct for protanomalous observers and included two pseudo-isochromatic lines for visualization. Each line contains three dots indicating colors that can not (or only with difficulties) be distinguished by a protanomalous observer.

Using the co-punct(s) published in literature (for an overview see reference [2]), we constructed pseudo-isochromatic charts using 10 symbols (0 through 9) and 10 different pseudo-isochromatic lines (spanning the display gamut). One example charts is shown in Figure 2.

Creating pseudo-isochromatic charts for recognition incurs additional problems that might be caused for all observers. The first one is that a non-distinct design might make two numerals easily confused, creating errors based on design, not color deficiency and the second is the difference in gamut range for different pseudo-isochromatic lines. We used the anonymous nature of our tests to exclude both issues. Here, the set-up asked all visitors to take part in the color vision test and thus a large number of color normal observers took the test. For these color normal observers, we looked at the error rates for different designs and pseudo-isochromatic lines and found no issues.

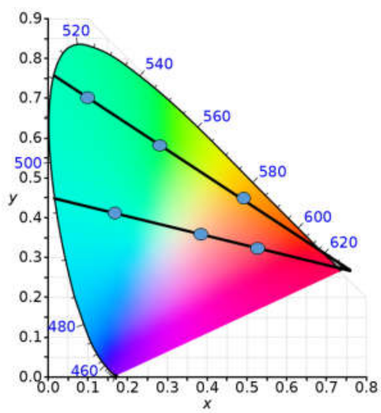

Figure 1: x,y-diagram showing two pseudo-isochromatic lines. (x,y-diagram taken from [1])

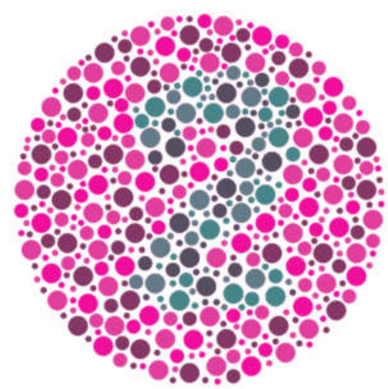

Figure 2: Example pseudo-isochromatic chart.

Chart Modification

After creating the base charts (we are re-using the same base-charts as in Reference [3]), we modified the white background between the dots and created 5 versions for each pseudo-isochromatic charts. One with background level 255 (original) plus the levels 196, 128, 64, 0.

Changing the background level reduces the overall image contrast for most of the new background levels. It is therefore not unreasonable to assume that the reduction likely will lead to a lower recognition rate for both color normal and color deficient observers.

Observer Selection

The experiments in Reference [3] where done largely in an anonymous fashion at public locations (see acknowledgement section) and thus only a small subset of the observers could be obtained for the new set of experiments.

In our case, we had access to 6 color deficient observers, all of them had participated in the first set of experiments and all of them had a strong color deficiency.

The statement about “strong” is subjective, but Figure 3 shows a typical Farnsworth Munsell 100 Hue result for one of those observers, indicating the severe deficiency.

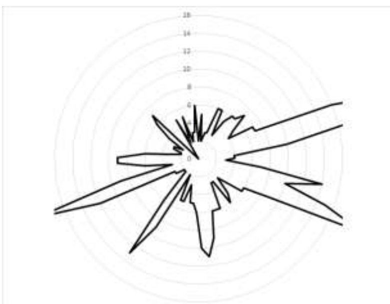

Figure 3: Farnsworth-Munsell test result for one of the observers.

Having only access to 6 color deficient observers leads us to consider our results “initial finding” in contrast to the larger set of observers for Ref. [3].

Experimental Results

To our surprise, the change in background level actually increased the recognition of the target numbers for the color deficient observers. The overall result is shown in Figure 4, where the overall percentage of correct answers is shown as a function of the background level (x-axis).

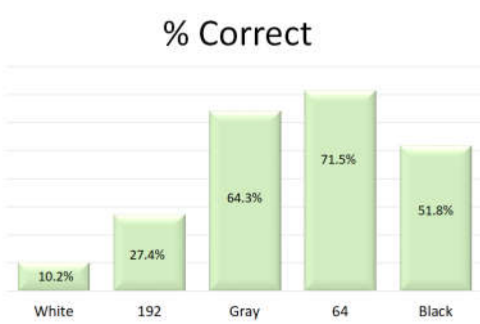

Figure 4: overall performance of color deficient observers on the pseudo-isochromatic charts as a function of background level.

For the small set of observers, it was easily possible to track the individual performance in a graph. This shows that the performance improves dramatically for all 6 observers as shown in Figure 5.

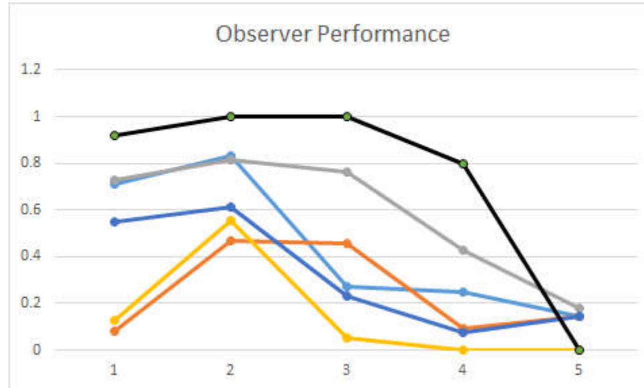

Figure 5: Individual performance of the 6 observers for the different background levels, where “1” indicates black background and “5” indicates white background.

Summary

The improved recognition rate of the modified charts is a surprise. Unfortunately, time did not permit to test what – if any – the performance difference is for color normal observers. These experiments should be performed (see acknowledgement) in the next few months..

Acknowledgement

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References

[1] By BenRG - File:CIExy1931.svg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=7889658

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Author Biography

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