Mini Project 1 Report

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1 Introduction

1.1 Problem

The Potsdam Transportation Company is notorious for being inaccurate in its ability to manage their bus lines. The company is currently responsible for the following routes: Red, Brown, Green, Yellow, Blue, and Purple. These routes service the areas of Massena, Canton, Ogdensburg, Watertown, Madrid, and Waddington. The company has concluded that the inaccuracies in their delay times stem from their colorblind operators selecting the wrong routes. Many operators do not speak English, so the company would like to avoid using text to differentiate the lines. The current interface that is deployed to the bus operators does not accommodate for these operators. As such, the operators are taking longer and are often selecting the wrong icon. These misclicks are causing riders to be notified of incorrect arrival delays. The company has stated that these issues are costing the company significant losses and they do not want to recolor the already established routes. A recent cost analysis showed that recoloring all of the lines would cost them approximately $\$100,000$.

1.2 New Interface

The company has hired us and tasked us with creating a new interface that is accessible to both the colorblind and non-English speaking employees; in hopes of relaying up-to-date information to the public on their mobile app and Twitter. Based on given budget restrictions, we are not allowed to use any category of border, shape, or change arrangements of existing icons. With a number of non-English speakers, the company has asked us to avoid using written words to differentiate the icons. Since non-English speakers & colorblind employees make up a small percentage of the entire company, any changes must be easily recognizable to the non-colorblind operators as well. The improved color must be in the same family of the existing colors in order to allow existing operators to remain comfortable with the new interface, and to prevent the causing the company to recolor all of their existing bus lines.

2 Need Finding

2.1 What is Colorblindness?

We first began to research what colorblindness is and the different types of the condition. When light enters our eyes through the cornea and passes through the lens and the transparent,

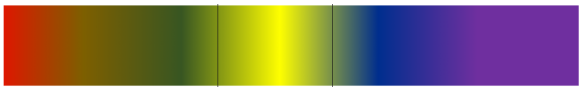
jellylike tissue of the eye to the wavelength-sensitive cells, known as the cones, in the back of the our eyes. The cones are known to be sensitive to red, green, blue wavelengths, hence where the term "RGB" comes from. These wavelengths produce a chemical reaction that causes the optic nerve in our eyes relay the information to our brains.[**1**] Colorblindness is caused by the lack of these wavelength-sensitive chemicals in our eyes. As a result, we would be unable to distinguish whichever chemical(s) is missing.

2.2 Consultation

The company had a colorblind employee, Sean Banerjee, give us a demonstration of their colorblindness. Given the results during the demonstration, we researched different forms of colorblindness to base our color selections on. During the demonstration, we concluded that Sean was unable to determine red when it was in close proximity with brown, blue when it was close proximity with purple, or green when it was in close proximity with yellow. We were also told that Sean does not know what purple looks like at all. We researched into different categories of colorblindness to find the closest example to Sean's colorblindness. We also based our modified color selections in accordance to the shades of each of the colors that he is able to recognize the best. To select our colors, we put them into a color wheel that would give us different shades near the input color. Red in close proximity with brown & blue was going to be the hardest as similar hues of red & brown look similar to Sean. Sean is also unable to see recognize purple so we had to choose our blue in accordance with that knowledge.

2.3 Need Finding

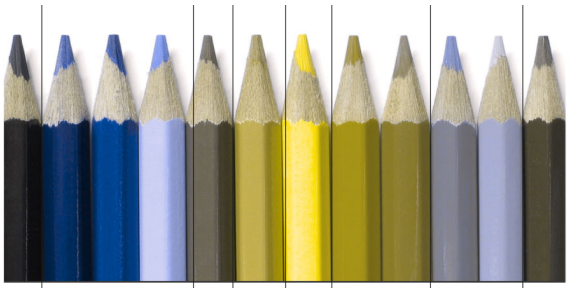
For our first need finding interview with Sean, we decided to do a couple categories of colorblind tests. We did a combination of faded gradients gradients, color separate gradients, and target choosing. For the different types of gradients, we had Sean separate where he saw the separations in the colors, as shown in Figure 1a & Figure 1b. We also brought in an actual colorblind test, Figure 2a, to confirm our suspicions of Sean's colorblindness. It is here where we realized that the original yellow is the best choice to keep constant in our revision of the interface. Sean was able to best distinguish the original yellow out of any of our other tests involving different shades of yellow. We also did target choosing examples where we had Sean pick the square that he thought was the target color given to him. The target choosing test is shown in Figure 2b. We chose to do these types of examples as they were closely related to the style of the interface design. We finished off the initial interview with doing only two gradients between the hardest combinations of colors: Red & Brown.



(a) Gradient using initial colors.

(b) Gradient to test examples of red & brown near each other.

Figure 1: Two examples of the gradient tests used in the interview, each for a different purpose.

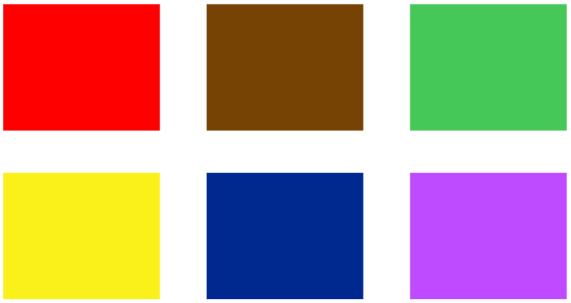


(a) The colorblind test used in the interview.

(b) One of the target color examples used in the interview

Figure 2: Two of the tests used in the need finding process.

We were unsatisfied with our initial color palette after the first interview, Figure 3a. We found that Sean wasn't able to distinguish our chosen blue near the purple, or the red near the brown. We decided to do more through testing involving these two combinations. We used to same target choosing and gradient separation tests as we had done in our initial interview. In the end, we used the results of the second interview to finalize our color palette for the interface that we thought was the best fit, as shown in Figure 3b.



(a) Our color palette after our initial interview.

(b) Final color palette after second interview

Figure 3: Our two revisions of the selected colors after each interview.

3 Interface Design

After finalizing our new colors, we began development on a testing interface to analyze our new color selections. We simulated a day working for the Potsdam Transportation Company as a bus schedule operator. The interface acted just like the system that the company already had in place, to ensure that data collection would be as accurate as possible. The original interface is shown in Figure 4. The company had two volunteers to perform testing on; one of their colorblind employees, Sean, and a non-colorblind employee, Natasha.

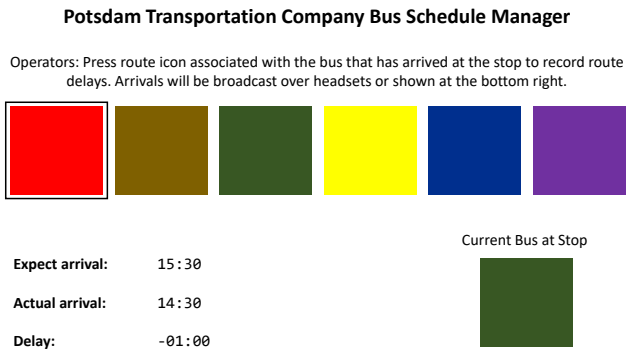


Figure 4: The original interface

In our interface, we displayed our 6 modified colors, just as the original's were displayed. In the bottom right of the screen, the target color would change every 3 seconds, and the person taking the test was expected to select the same color from the list of colors above. The colors were randomized into a list, with each color displaying 8 times, for a total of 48 color displays. Our modified color interface is shown in Figure 5.

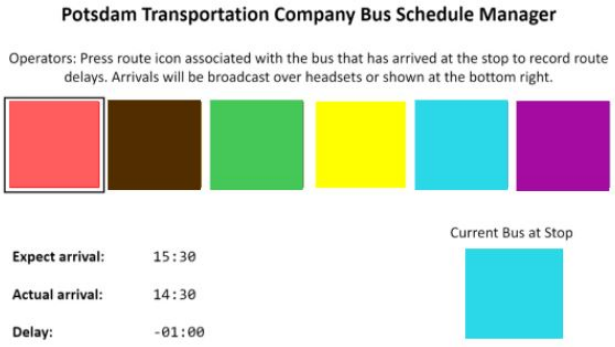


Figure 5: The interface with modified colors

The interface collected both accuracy and time data from the user. In an attempt to combat fatigue from the user, we kept each test's length at approximately 3 minutes. This allowed us to collect a decent sample size while also keeping user fatigue to a minimum. The user was asked to complete two tests, one with the original interface in Figure 4 and one with the modified interface in Figure 5. The data was then compiled into excel spreadsheets for analysis.

4 Data Analysis

To begin our data analysis, we first hypothesised the results. We believed that the modified interface would not only lead to more accurate results, but also lead to a quicker reaction time.

4.1 Accuracy

Beginning with accuracy, our hypothesis held true. For Sean, his accuracy from the original interface was just above 60%, as he managed to correctly identify 30 of the 48 color targets. Sean also pointed out that the colors he was given appeared to be moving in order, without randomization. After checking the randomized color file, that was partially true. There were 2 instances in which the colors moved in order, from left to right. These happened to be back to back, and it is very possible that Sean was able to game the system to improve his score. If those 16 data points are left out, Sean would have scored a 19 of 32, which reduces his accuracy to slightly below 60%, so it is safe to assume that it didn't have a significant impact on our results. Shown in Figure 6 is Sean's accuracy per color in both the original and modified interface. The values represent the percent correct expressed in decimal notation. There were some notable patterns that occurred within Sean's data. The biggest thing we noticed was the confusion of red as brown after being displayed a blue. This occurred 3 times within our data, and all 3 times Sean mistook red for brown. This was not the case if a red tailed either yellow or green, and didn't occur consistently for either brown or purple. Sean also confused red and green often, which helped to give us insight into the type of colorblindness that he has.

Color	**Red**	**Brown**	**Green**	**Yellow**	**Blue**	**Purple**
Original	.125	.625	.375	1	.75	.875
Modified	1	1	1	1	1	1

Figure 6: Sean's accuracy per color for each interface

As pictured in Figure 6, Sean's accuracy improved to 100% for every color in the interface. He correctly selected all 48 color targets. Sean's ability to correctly identify the line color improved drastically from the original colors.

Color	**Red**	**Brown**	**Green**	**Yellow**	**Blue**	**Purple**
Original	1	1	1	1	1	1
Modified	1	1	1	1	1	1

Figure 7: Natasha's accuracy per color for each interface

We also collected data from Natasha, who is not colorblind, to ensure our colors didn't hurt the accuracy of non-colorblind individuals while attempting to create colors that were easily differentiable to someone who is colorblind. To begin with Natasha's original color test, she correctly identified all 48 targets. We expected Natasha to perform well with the original interface, and that expectation held up. Natasha was also perfect with the modified, so we were able to conclude that the new colors were still easily recognizable as the original bus line colors. Natasha's accuracy is displayed in the chart in Figure 7, where she was perfect in both tests.

4.2 Time Delay

We hypothesised that the amount of time it would take the user to select the color would decrease, since the colors would be easily recognizable. Unfortunately, during data collection,

our code did not collect accurate enough time data to be able to tell a significant difference. We know that the average time delay for all color targets in a specific test was less than a second. Both Sean's original and modified color data showed a time delay of less than a second. Natasha's time delays were also less than a second for both tests. There were only 3 instances that our code recorded a delay larger than a second, and all occurred on Natasha's original data. We do not have enough data to state that their was any statistical significance with the time delay.

5 Conclusion

Our data analysis shows that our interface is accessible to those who are colorblind. We managed 100% accuracy with our modified colors, a significant increase from the original colors which had an accuracy of approximately 60%. Our time data is not accurate enough to conclude whether or not the time delay was significant. For the non-colorblind participant, there was no change in accuracy, which shows that the interface is still accessible to non-colorblind individuals. We are able to conclude, based on our accuracy data, that our interface is successful in resolving the issue faced by the Potsdam Transportation Company.

5.1 Improvements

The most glaring whole in our data collection is our time data, or lack thereof. In a future test, more accurate time data should be collected to allow for analysis on the time delay. Improvements could also be made to the testing interface to make the experience less cumbersome for the participant. Removing the standard 3 second delay and allowing the user to move at their own pace could significantly improve data quality on larger samples by reducing boredom and frustration. Gathering more information on other members colorblindness would also be important. These colors were well optimized for Sean's colorblindness, but it may not be so effective for others.

References

[1] Mayo Clinic Staff, *Color Blindness*, `https://www.mayoclinic.org/diseases-conditions/poor-color-vision/symptoms-causes/syc-20354988`, (January 25, 2021).