Potsdam Transportation Company Modifications - CS459 Mini Project 1

ROSALINA DELWICHE*, Clarkson University, USA
HOLLY ROSSMANN*, Clarkson University, USA

The Potsdam Transportation Company hired us to improve the colors of the 6 transportation routes to make it easily accessible to colorblind individuals. In order to do this, we underwent a series of interviews to get a basis on the user's colorblindness extent. These interviews provided insight to the need for modification, as well as ways to improve. Given this information, we implemented two series of tests for one colorblind individual and a non-colorblind individual. Like we initially assumed, the original interface led to increased error. The new interface testing tested a wide array of possibilities to aid in decreased error. By analyzing the responses from both individual computed from the trials, we were able to create an improved version that has a higher probability of success.

1 INTRODUCTION

The Potsdam Transportation company has illustrated concern over its current bus schedule. The current bus schedule includes 6 routes represented by the following colors - red, brown, green, yellow, blue and purple. When an operator arrives at a stop, the operator must click the corresponding button located on the bus to the line which they are operating. This is used to compute delay time. However, some employees may take the longer than average to select the corresponding line and/or click the entirely wrong icon. This leads to an influx of errors and inaccurate delays.

One of the solution thought of by the company was to label the buttons. However, not all operators speak English. Another solution was to repaint the lines. However, based on cost analysis, this is not a plausible solution. Instead, we - Rosalina Delwiche and Holly Rossmann, were hired to modify the route colors. In the briefing, it was determined the colors of each individual button can be changed, but it must stay within the original color family. In addition we could not implement any of the following changes to- border, shape and arrangement.

This report will discuss what steps were taken to design and implement a new Bus Schedule Interface that would be the best fit for the Potsdam Transportation Company. We will highlight needs finding and design, implementation, and data collection of both the original and new interface. Given this information, we perform statistical analysis through a series or box plots, bar graphs, probability charts and consider the impacts which the independent variables may exhibit. In the end, we will combine our findings throughout the process to provide an new, effective collection of buttons.

1.1 Needs Finding Interviews

Before we conducted our need finding interviews, we first thought of topics to discuss. Generally speaking, need finding is used by development teams to be able to understand exactly what it is a target user wants. Since our team was tasked with creating an interface to aid colorblind individuals, it was imperative for us to interview an employee that was colorblind. For this interview, our goal was to find what concerns the interviewee demonstrates with their current situation, and what they believe the Potsdam Transportation Company needs to improve upon.

Authors' addresses: Rosalina Delwiche, delwicrg@clarkson.edu, Clarkson University, 10 Clarkson Avenue, Potsdam, New York, USA, 13699; Holly Rossmann, rossmah@clarkson.edu, Clarkson University, 10 Clarkson Avenue, Potsdam, New York, USA, 13699.

1.2 First Interview

1.2.1 *Questions.*

For the first interview, we aimed to get a sense of the visual color spectrum that our user, Dr. Sean Banerjee, was able to see. The focus of this interview was to determine if different shades of colors had an impact on his ability to tell one from another. For the purpose of this project, we only curated questions based on the six original interface colors - red, brown, green, yellow, blue and purple.

In the interview, we showed him two slides of the six original interface colors, and asked him to name them to his best ability. The interview progressed by showing a color wheel, and asking him to identify how many individual colors he sees. Next, we provided Dr. Banerjee with nine different shades of each color organized into six different cubes. He was asked to identify the color family of each cube, and chose a color he was most certain belong to a specific color family. After this, we showed him three modified color palettes with varying shades of the original six colors. Here, he was tasked with identifying and labelling each color to the best of his ability. In the last color identification test, we showed Dr. Banerjee a few shades of each of the six color families, and asked if he could sort them under the corresponding labels.

1.2.2 *Findings.*

From this first need findings interview, we gained valuable information pertaining to our colorblind user's limitations of color categorizations. This was best emphasized when we asked him to identify different colors of the modified palettes.

Starting with red and brown, we noticed that lighter shades of red are more likely to be classified as green. Out of the three reds given, only one was labelled correctly and the other two were labelled as green instead. The correct red was the current red used by The Potsdam Transportation Company and it is high in contrast and vibrancy. We further saw the difficulty to identify red and browns, based on the brown identifications. Of the three browns shown, he labelled them all red. These browns were all of the lighter variety, so we took note of this and kept in mind that dark shades might be better when we run our data collection.

Moving to yellow and green, Dr. Banerjee correctly identified this color one out of three times it was shown. Earlier in the interview, he had explained that he was able to correctly pick out vibrant yellows easilier. Due to this and other previous planning, the yellows shown in the palettes were all contained high contrast and high pigmented. The two incorrectly identified yellows were labelled as green instead.

He, however, was able to correctly identify three of the four greens shown to him. These were all lighter shades of green.

While the other color shades thus far were roughly the same, we decided for blue and purple we wanted to test the difference in detection between light and dark. Like Dr. Banerjee had predicted during an earlier question, he was only able to identify light blues. When the blue was a darker shade, he incorrectly labelled it as purple. Similarly, when given both light and dark shades of purple, we found he was only able to correctly identify dark shades of purples. Otherwise, the light purples may incorrectly be labelled as blue. From this, we were able to understand that the ideal interface should be one that has a light blue and dark purple combination in it, to minimize possible error in detection.

Overall, we determined that the possible color pairings are red/green, blue/purple, green/brown, yellow/green and red/green/brown. This is important information, as it was clear our interface tests should focus on. Furthermore, we learned that we needed to put emphasis on finding a solution to these problematic colors. In addition, we needed to be cautious of these potential problem areas, as the Potsdam Transportation Company colored its routes in order of red, brown, green, yellow, blue and purple - which makes every neighboring color a problem to the surrounding ones.

1.3 Second Interview

1.3.1 Questions.

In the second interview, we took a different approach. Previously, we focused on the identification of colors, and the extent to which the user was able to tell color shades apart. However, this time, our goal was to gain a broader understanding of what life is like as a colorblind individual. Due to the nature of the interview intentions, we had a purely question and answer based session that steered away from the simplicity of labelling colors comprised of 10 questions.

The questions asked pertained to Dr. Banerjee's life as a colorblind individual. Some questions asked related to potential systems in classifying colors of objects quickly, and others asked were more broad based on how his life is impacted by not being able to see colors like the majority of the population. We also asked clarification questions about his environment. We asked him if his laptop contained any display modifications and if his glasses were tinted to aid in color correction. In addition, we asked why vibrant yellows and light blues standout to him more than others, as determined in the previous interview. Lastly, we asked him if tints and shades help in identifying particular colors over others.

1.3.2 Findings.

We discovered that Dr. Banerjee relied heavily on arrangement of colors. For example, when driving, stoplights are troublesome due the arrangement of red, green and yellow. In these situations, he relies on the position of each color to quickly determine what color the light is. Another example is when in self-checkout lines, he has learned to memorize what corner the yes and no buttons are in.

We also learned he characterizes colors based on objects in his everyday environment. Light blues are more easily identifiable to him because he knows it is the color of the sky. Therefore, when faced with a sky-like color, he can more confidently label it as a blue. Similarly, he is more comfortable with vibrant yellows due to the fact that he owned a bright yellow car.

These questions solidified potential problem areas and allowed us to understand the struggles that colorblind individuals face. Moreso, we learned that it may be advantageous going forward if we kept an eye on the success of these "natural" colors, as they may have a higher success rate than others because of the repetitive placement throughout ones daily lives.

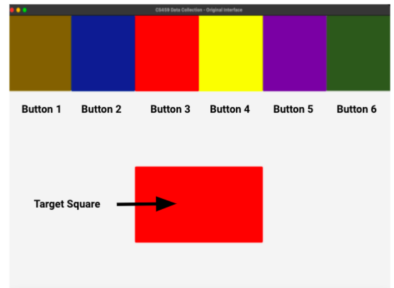


Fig. 1. Original Interface Phase 1 Example Trial

2 DESIGN OF INTERFACE

2.1 Designing the Original Interface

We designed the basic layout for the original interface in Javafx. The original interface utilizes the 6 given hex values currently used by Potsdam Transportation Company corresponding to red, brown, green, yellow, blue and purple.

To start off, we created the display for the buttons. The display features 6 buttons of the same size side by side, as illustrated in Figure 1. We decided not to include spaces in between the buttons because we found that would offer an advantage, thus increasing bias. Instead, we put them side by side and put the "Target Square" in the middle. The Target Square was carefully chosen to be twice the width of each individual button, the same height, and centered to be equidistant to all buttons. We hoped that this would decrease reaction time so the user can focus on the screen as a whole instead of looking to the side.

Next, we added functionality to the display through phases. The first phase, also illustrated in Figure 1 included all 6 colors. The goal was to match the Target Square to the corresponding button by clicking the button which is believe to be correct. In Figure 1 the user would click Button 3. Once an answer is selected, the interface moves onto the next trial. For Phase 1 we implemented 40 trials, $n = 40$. Each trial features randomization of the arrangement of colors shown and the the Target Square color.

After testing the interface as a whole with all 6 colors, we decided to branch off and create 15 more phases. The 15 individual phases each feature 2 color pairings. For these phases 3 buttons were Color 1 and 3 buttons were Color 2. In these phases, randomization was still upheld. The trial amount for these overall varied. Predicted trouble pairings of red vs. green, blue vs. purple, green vs. yellow, green vs. yellow as determined by the Needs Finding interview were phases 3 - 7 and given 15 trials. The 11 remaining color combinations were given 10 trials.

Overall, the original interface aimed to test the 6 colors as a whole and individual pairings with a total of 210 trials split up meticulously throughout.

2.2 Designing the Modified Interface

The Design of the Modified Interface shared several commonalities with its counter interface, The Original Interface. The same layout was shown and the same goal was to be me through a series of phases. Phase 1, with all 6 colors was modified to show different variants of each color predicted to yield a higher success rate and trial size was increased from $n = 40$ to $n = 60$.

Unlike the Original, a new trial was put in place with $n = 40$ for the purpose of testing the correct responses for Phase 1. This was implemented to see how the colors guessed correctly would perform alongside the others and if the accuracy would decrease.

Next, we implemented 6 more phases. Phases 3 - 6 were set to test the Predicted Trouble pairings as done in The Original Interface with 3 buttons of Color 1 and 3 buttons of Color 2. The 4 sets of pairings were red vs. brown, yellow vs. green, blue vs. purple and green vs. red. These phases had 20 trials each. For Phase 7 we tested red, green and brown with each color family filling 2 squares.

The last key difference from the Original was Phase 8. Phase 8 was similar to Phase 1, however, the color value for the Target Square was not displayed on any of the buttons. This was implemented for the purpose of determining whether the users can associate different variants of one color family to each other.

2.3 Recording Data

As the users progress through the both the Original and Modified Interface, the data is constantly being recorded. The program writes to a text file after each press of the button. Each line of the text file represents a different phase with start time, end time, total time elapsed (as defined by end-start), target color hex value and classification, color chosen hex value and classification, if it was guessed correctly, phase number, trial number within phase and the hex value of the 6 buttons in order. After the last trial, the interface closes and the user is asked to send the text-file back to us for analyzing.

3 ANALYZING THE INTERFACES

3.1 Introduction

Once we received both Sean and Natasha's data, we transformed the format from a text file to an excel spread sheet. A column was created for each type of information collected, while each row was an individual trial. From this, we were able to analyze. Phases were considered individually, then as a whole.

3.2 Original

3.2.1 *Phase 1.*

Since both the Original and Modified Interface contained Phase 1, we were able to generate a general excel equation that takes into the account the target color classification and chosen color classification. From this we were able to create a table with the Target Color and the color selected by the user.

Chosen Color

Color Shown	Red	Green	Blue	Yellow	Brown	Purple
Red	5					
Green		5		1		
Blue			3			
Yellow				9		
Brown					9	
Purple						8

[Natasha]

Chosen Color

Color Shown	Red	Green	Blue	Yellow	Brown	Purple
Red	2	1			2	
Green	2	1				
Blue			8			2
Yellow				7		
Brown		1			6	
Purple			5			3

[Sean]

Fig. 2. Phase 1 Original Interface Results

The results for the Original Interface are shown in Figure 2 where the black boxes represent correctness. For Natasha, she got $\frac{39}{40}$ correct. The one incorrect was from a trial where green was shown and she picked yellow. While there was one wrong, there is insufficient evidence to conclude Natasha has color confusion. However, the same can not be said for Sean. The accuracy of Phase 1 for Sean was $\frac{27}{40}$. Looking further at the breakdown of the 13 incorrect guesses, it is evident that there is a large amount of incorrect guesses for color combinations such as blue and purple. Of the 8 trials purple was shown, Sean chose Blue for 5 of them. Similarly, in the 10 trials blue was shown, Sean chose purple 2 times. Thus, it is evident there is Blue and Purple confusion. In further analyses, the same was demonstrated for red vs. green and brown vs. red. In one trial Sean choose green once when brown was the Target Square. To determine whether this was by accident or on purpose, the next 15 phases were analyzed.

3.2.2 *Beyond Phase 1.*

In the next 15 phases, were pairings of two colors with 3 buttons of one color and 3 buttons of the next. The success rate for each phase was computed by having excel compute it as the following $p = \frac{trial - incorrect}{trial}$, where trial is the amount of trials for the phase and incorrect is the number incorrect guesses for that phase. A result of 1 would indicate no confusion, as the number of incorrect guesses is 0. Thus, results with $p < 1$ need further analysis.

For Natasha, there were 4 color combinations that had a probability of less than 1. The possible problematic pairings were blue vs purple with $p = \frac{12}{15}$, red vs. yellow with $p = \frac{9}{10}$, green vs. brown with $p = \frac{8}{10}$ and purple vs. brown with $p = \frac{14}{15}$. Although results such as these may indicate trouble pairings, this is not the case. Further analysis of these provide the results were negligible. The green vs. purple phase followed the green vs. brown. On the third to last trial in green vs. brown phase, the reaction was $t = .76$. However in the last two trials of this phase it was $t = 0.0040724$ and $t = 0.0050175$. In the green vs. purple phase, this continued to happen for the first two trials with the reaction time $t = 0.002871$ and $t = 0.0023457$. These times are almost impossible, and thus we could not include

Chosen Color

	Red	Green	Blue	Yellow	Brown	Purple
Red	11					
Green		12				
Blue			6			
Yellow				8		
Brown					14	
Purple						9

Color Shown

[Natasha]

Color Chosen

	Red	Green	Blue	Yellow	Brown	Purple
Red	9					
Green		4		2		
Blue			8			
Yellow				14		
Brown					10	
Purple						13

Color Shown

[Sean]

Fig. 3. Phase 1 Modified Interface Results

them in determining possible difficulty and instead assumed they were due to mouse errors. Thus, no green vs. purple and and green vs. brown difficulty was detected. Similarly in the purple vs. blue phase, two trials had a reaction time of $t < .007$ seconds and could not be used. As per the wrong trial in red vs. yellow $t = .76$, Phase 1 doesn't support this. Therefore, no problematic pairings were detected for Natasha.

For Sean, there were also 4 possible problematic color combinations. The possible problematic pairings were red vs. brown with $p = \frac{14}{15}$, blue vs. purple with $p = \frac{11}{15}$, green vs. red with $p = \frac{9}{15}$ and green vs. brown with $p = \frac{14}{15}$. All incorrect guesses were humanly possible, unlike observed with Natasha. All of these color combination were also observed in the needs finding and phase 1 to a high degree except for green vs. brown. In both Phase 1 and the individual green vs. brown phase, Sean got one wrong. However, this was not observed in the Needs Finding so we could not confirm difficulty between these colors and kept this in mind.

3.3 Modified Interface

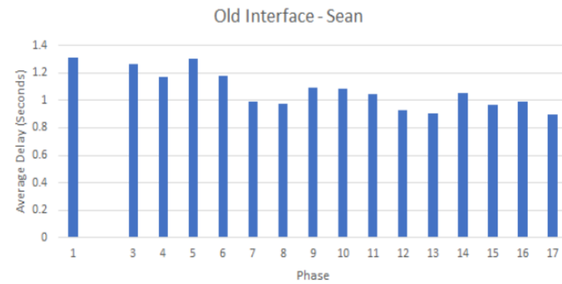
3.3.1 Phase 1.

For the Modified Interface, we followed the same approach as in the Original Phase 1. The results are shown in Figure 3.

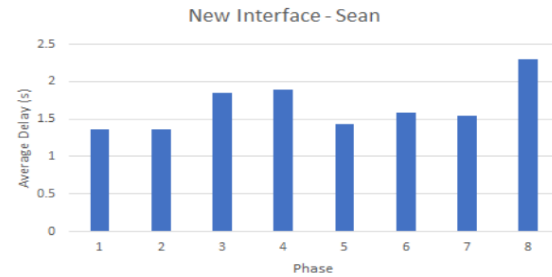
For Natasha, there was 100 % accuracy in Phase 1; no colors were mistaken for each other. However, for Sean this was not the case. Phase 1 indicated trouble with green vs. yellow pairings. Figure 3 shows that when green was shown as the Target Color, yellow was chosen in two trials. The wrong pairings were the following written as Target Square color vs. Color Chosen - #ffffbf (green) vs. #cfffe5 (yellow) and #9cfc00 (green) vs. #ffff000 (yellow). With further analysis, it was concluded that greens of similar intensity to yellow were not ideal. In addition, light yellows, as Sean also demonstrated confusion with were also not ideal. It was clear Phase 1 of the original interface to the new interface significantly improved from $p = \frac{27}{40}$ to $p = \frac{58}{60}$ for Sean and from $p = \frac{39}{40}$ to $p = \frac{60}{60}$ for Natasha.

4 ACCURACY AND DELAY

For Sean, the accuracy for the original interface was 87.7% and the new interface was 87%. For Natasha, the accuracy new interface



[Old]



[New]

Fig. 4. Average Delay Times per Interface Phases

was 96.2% and the new interface was 98.7%. While these results do not indicate significant improvement, we were not entirely aiming for perfect accuracy overall, but within specific color combinations instead. Some colors were specifically put into the interfaces to be troublesome colors. In addition, some were there to give the most variety in color shades even if we knew prior that they would be tricky. The overall accuracies are beneficial because they allow us to understand whether most shades are compatible with others. But, due to the nature of our new interface, they do not tell the entire story behind how well each user did during the data collection. A more lengthy and detailed look into the accuracy data by each hex color specifically played a significant part in our decision to assign the new interface colors.

In both of the interfaces, three out of four times the wrong choices took longer to make then the correct choices. From this, we can infer that, while the choices were not 100% accurate, the users were able to quickly identify certain shades of colors, and took more time in contemplation before selecting an incorrect choice. The only time the wrong selection delay time was faster occurred with Natasha in the original interface. We believe, however, that after observing multiple fast and incorrect selections in a row, this error could have been due to a mis-click or stuck mouse.

5 PHASE ANALYSES

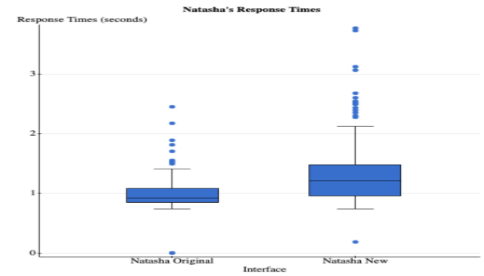
5.1 Average Delay Time

The most useful analysis of delay times lie within each individual phase. To begin, we recorded and graphed the average delay time in relation to the original interface colors. The 17 phases represent the comparison of each of the 6 hex colors against each other, to understand what, if any, issues the user had with deciphering between color families. Figure 4 shows the average delay times per phase in both the old and new interfaces. Looking at the general trend in data between our colorblind and non-colorblind individuals, we noticed that the non-colorblind individual took less time to select their answers in every single phase. Additionally, we noticed a slight downward trend in the delay times as the colorblind individual progressed through the phases. We believe this was partially due to them getting acclimated with the program and becoming more comfortable with the color selection process. That being said, we still noticed some phases that had longer delay times, signifying potential bad color combinations. These combinations were red and brown, yellow and green, blue and purple, red and green, and green and brown. This confirmed the hypothesis that we figured in the beginning of this process, with the data to back it up.

With the new interface, we followed a similar procedure. In all phases, the non-colorblind user had lower average delay times. Looking particularly at the colorblind user's data, we noticed that the phases with the longest delay times were red versus brown, yellow versus green, and phase 8, where the target color was not among the six options, and a color of the same family must be chosen instead. Phase 8 took the longest of all phases, with an average delay time of 2.5 seconds. The data in this phase is the most important, as we can now infer that the user had to put more thought into color identification in order to correctly pair it to a same-family color of a different shade. In these problem areas, we were able to go into the data of the phases to particularly look at why the delay times were as slow as they were, and what target and chosen colors caused this conflict to arise. We took those considerations to mind when configuring our new interface to ensure we did not assign two colors that worked excellent individually but failed when it came to the comparison between one another.

Overall the reaction times are illustrated in Figure 5, including median, Q1, Q3, standard deviation and interquartile range. For Sean, the median response time for the Original interface was 1.05 seconds and 1.3 seconds for the Modified. However, for Natasha the median response time was 0.93 seconds for the Original and 1.2 seconds for the Modified. The Box plots, also located in Figure 5 illustrate the distribution of reaction times for both interfaces per individual with Original on left and Modified on right. For the Original Interface, there were a total of 12 outliers for Natasha and 10 for Sean. In Sean's case the outliers were beyond the median and the success rate of those 10 outlier trials was $\frac{6}{10}$. For Natasha, the success rate of the 12 outliers was $\frac{7}{12}$. This shows for the Original for both Natasha and Sean, in the case of outliers, either a response time above $Q3 + 1.5(Q3 - Q1)$ or below $Q1 - 1.5(Q3 - Q1)$ is more likely to have an incorrect selection compared to the overall accuracy.

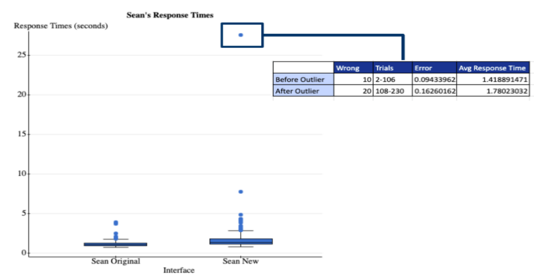
For the Modified interface, a higher amount of outliers was observed. Many of reaction times for both Natasha and Sean were higher than $Q3 + 1.5(Q3 - Q1)$. With Natasha this was not as much of a concern because the highest reaction time was around 3 seconds and accuracy overall was almost 99%. However for Sean, in one instance in one trial it took him around 28 seconds to make a selection and the selection was incorrect. The 2 trials proceeding were also outliers with response times of 3.4 and 7.5 seconds. Likewise, they were all incorrect. The overall success rate of the outlier trials for Sean was $p = \frac{28}{16}$. However, we noticed some discrepancy before and after the 28 second response time occured at trial 107. The Boxed in



[Natasha]

Column	n	Mean	Std. dev.	Median	Range	Q1	Q3	IQR
Natasha Original	209	0.98145021	0.29144166	0.9272198	2.4548179	0.8544054	1.0918435	0.2374381
Natasha New	229	1.3270596	0.51579522	1.2137993	3.5946841	0.9657857	1.4829827	0.517197

[Natasha]



[Sean]

Fig. 5. Response Times

Column	n	Mean	Std. dev.	Median	Range	Q1	Q3	IQR
Sean Original	209	1.1214371	0.36942494	1.0471651	3.2310006	0.9090975	1.2309102	0.3218127
Sean New	229	1.7274667	1.9134011	1.3002361	26.829492	1.1351344	1.8262862	0.6911518

[Sean]

point in Figure 5 illustrates this. Leading up to trial 107, the error rate was,e, was $e = 0.094$ with an average response of $t = 1.419$. In this case t represents the mean, which is likely to be higher than the median. So this is no cause for concern. However, after trial 107, error rate increased to $e = 0.162$ and time to $t = 1.78$. This indicates there was a change in both time and error rate to some degree. On further analysis, this jump of both reaction time and error rate can be attributed to Phase 8. The outlier occured in phase 8 and the success rate of the phase was $\frac{1}{2}$. In addition, there was higher than normal response times, with the average being above $t = 3$. This indicates Sean has more trouble associating variant of colors to each other and may take more time and guess incorrectly. Thus, it highlighted the importance of keeping the colors constant between the buttons and lines and analyzing the data to pick one hex value per color family.

6 COMBINATIONS

When selecting the colors for our final interface, we wanted to ensure that there would be no blatant issues between two problem colors. To focus on this, we pulled each wrong color family selection for each phase, and displayed them together to be able to observe any similarities.

With the yellow and green combinations, we noticed that the same shades and vibrancy are not a good mix. For example, light green and light yellow very often were mistaken for each other, and likewise with a dark green and dark yellow. From this, we

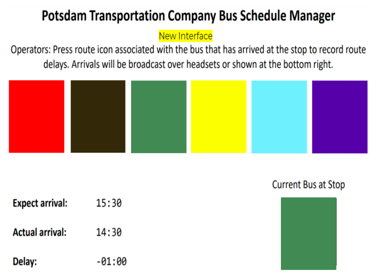


Fig. 6. Final New Interface

understood that when selecting a yellow and green, we must ensure that the shades are different enough that there would be a large enough contrast between the two.

For the red and brown combinations, we quickly noticed that a warmer-toned brown fared very poorly when compared against reds of many different shades. From this, we learned that if we wanted a successful brown, it must be cooler toned and very dark in contrast to the red. The red, on the other hand, should either be of the lighter variety, or one of higher vibrancy, as reds of those descriptions were more accurately predicted than others.

Lastly, we also focused on blue and purple combinations. Like we had discovered in our need finding interviews, light blues and dark purples worked the best together. If the colors were of the same shade they were hard to distinguish between, and if there were dark blues and light purples, the two would be mistaken for each other. From this, we solidified the idea that we should use a sky blue for our interface, as well as a darker purple that was several shades darker from the blue, without being too dark that it could potentially be mistaken for a brown.

7 SELECTING THE FINAL INTERFACE

With all of the color combinations factored in, we were able to decide on the six final colors for the new and improved interface. Considering all of the data we had gathered and the conclusions we had gathered from our need finding interviews, we determined the new colors to be as follows: a vibrant red (#ff0000), dark brown (#332808), medium green (#418a53), vibrant yellow (#fbff00), light blue (#6ef0ff) and dark purple (#5b009c). The results is shown in Figure 6.

We believe that these colors will be a good fit together, as they are distinct enough for non colorblind users, while being more distinguishable to colorblind individuals. We feel that the new interface will be successful at reducing errors based on the statistical analysis that was conducted. That being said, if we had been able to expand on this project more, we would have liked to conduct a final interface data collection, where these six colors were tested exclusively against delay time and accuracy to completely ensure they are the best fit for the Potsdam Transportation Company.

8 SENSITIVITY ANALYSIS

While a lot was taken into account to come up with a modified interface, different values of the independent variable, color, can play a role on the dependent variable. Since the color was constantly changing, the user did not know what to expect. While this is good in terms of eliminating bias for memorization, it may take the user longer because they have to examine all colors first before choosing a selection. In addition, the amount of trials, $n = 210$ for the Original Interface and $n = 230$ for the Modified Interface may lead to error later on. The Original Interface took Sean 4.26 minutes to complete and Natasha 3.6 minutes. The Modified Interface took Sean 6.7 minutes to complete and Natasha 5.2 minutes. Although these times are not excessive, with the constant changing of the interface, it is possible it could lead to boredom. Given this analysis, it was clear on what to do for Future Work.

9 FUTURE WORK

In the Future, we would like to expand on our data collection. We would like to sample more people through stratified random sampling based on different types of colorblindness. This is important to do because the majority of the population is not colorblind, so simple random sampling would likely result in sampling few colorblind individuals. In addition, we would like to increase the sample size of trials, while providing breaks. Increasing the sample size helps to normalize the data and get the true probability of choosing a color correctly. Breaks limit the tiredness and boredom of the user which plays a role on whether they guess correctly. Ideally, this would be done in a controlled environment to eliminate possible bias such as distraction. The controlled environment would be the same for all users. Lastly, we would like to implement a final phase in the Modified Interface to calculate the best color for each individual and then tests it out with a set amount of trials. This is important for us to include because testing on a wide array of types of colorblindness is likely not to yield a one fit all approach. This was a very interesting project overall, and there is an expansive amount of topics we could focus on in the future to make a more accurate and in-depth approach to a color-blind accessible interface.