CS459-MP1-Report

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1 Problem Overview

The original interface was not suitable for every user to use, so we had to change the interface. When the user checks the color of the bus arriving at the stop, they can select the same color at the interface. However, in the case of colorblind users, it may take a long time to select the color or they may select a wrong color because it is difficult for them to distinguish colors. For this reason, wrong information is often provided to the users. Adding borders, adding shadows, changing shapes, and rearranging colors were not allowed when creating a new interface. Therefore, we had to change the colors so that the colorblind users could sufficiently distinguish the color. The six route colors are red, brown, green, yellow, blue, and purple.

2 Need-Finding Interview

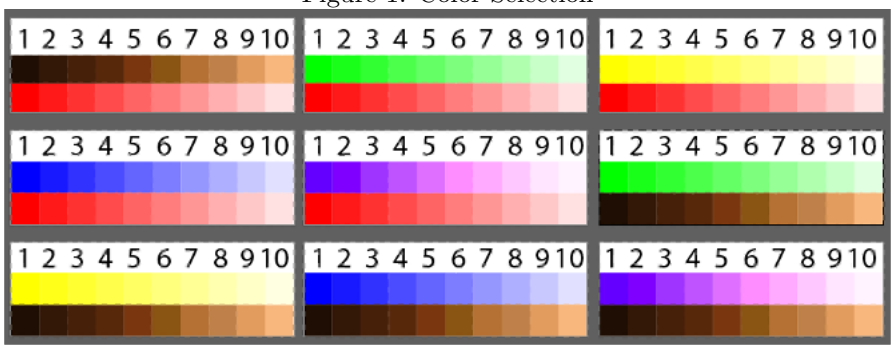
A need-finding interview was conducted to determine which colors are well distinguished and which colors are not well distinguished by colorblind users. The interview was conducted through Zoom. Interview documents were created in advance using Google Docs so that the interviewee could follow the interview well, and the document link was delivered through Zoom chat. We asked the interviewee to share his screen to check how he conduct the test in real time.

First, an officially certified color blindness test was conducted. This was to determine what type of colorblind the interviewee has, and then to identify which colors a person with that type of colorblindness cannot distinguish well. A total of 31 questions were answered, and we recorded the colors he could not distinguish at all, colors that took more than 1 second to distinguish, and colors that he distinguished well. As a result of the test, 'Strong Protan' came out.

Second, a color selection test was conducted. We created options for two of the six colors(red, brown, green, yellow, blue, purple) using Illustrator. All combinations were created because colors had to be distinguished well regardless of the arrangement of colors. We asked the interviewee to choose two colors

from each row that he can see the most difference. Numbers were assigned for convenience. The results were as follows.

Figure 1: Color Selection

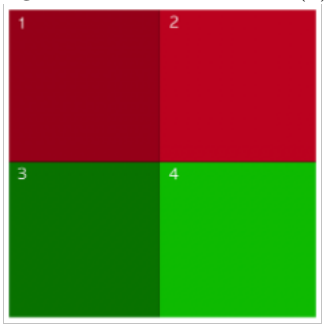


Red-Brown	1-1	Red-Green	1-1	Red-Yellow	1-1
Red-Blue	1-1	Red-Purple	1-1	Brown-Green	1-1
Brown-Yellow	1-1	Brown-Blue	1-1	Brown-Purple	1-1
Green-Yellow	10-1	Green-Blue	1-1	Green-Purple	1-1
Yellow-Blue	1-1	Yellow-Purple	1-1	Blue-Purple	10-1

Table 1: Color Selection Result

Finally, a color option was created by using Photoshop to see if lowering the brightness of the color unconditionally helps distinguish the color. The interviewee chose 1 and 4.

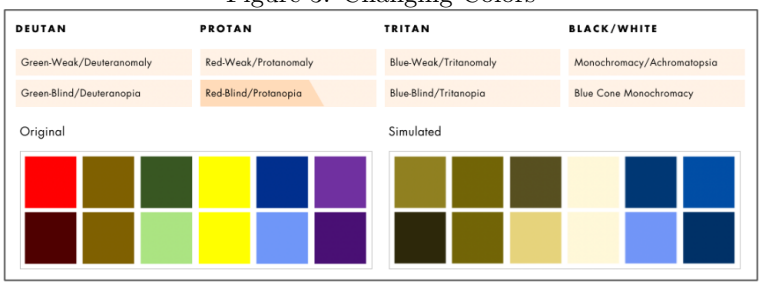
Figure 2: Color Selection (2)



3 Experimental Setup

Information on the user was collected and analyzed through a need-finding interview. For the colorblind user, it was difficult to distinguish between red and green, dark red and black, green and black, dark purple and black, and red, green, purple are likely to be seen as black. Also, lowering the brightness of the two confusing colors did not necessarily make the distinction easier. Therefore, it was concluded that it is important to change the color so that red and green, green and yellow, blue and purple are well distinguished. We changed the color little by little by referring to the color selection result, and a website(https://pilestone.com/pages/color-blindness-simulator-1) that provides simulation on how the actual colorblind person views the color was used.

Figure 3: Changing Colors



As a result, red was changed to #7B0E0E, brown was changed to #7F6000, green was changed to #ACE483, yellow was not changed(#FFFF02), blue was changed to #7096f9, and purple was changed to #491074.

HTML/CSS/JavaScript was used to make original and new interfaces. When the user presses the Start button, the test begins. Each time a color is pressed, the color to be selected is changed, and the arrangement of the six colors is also randomly changes. The user has to select the color for 300 times in total. It shows how many times the user have selected in total during the test. When the test is over, the CSV file is automatically downloaded, and if the user fails to finish the test due to the time limit, he or she can press the download button so that the CSV file can be downloaded. The CSV file contains data on the color arrangement, the color to be selected, the color actually selected by the user, correctness, and the time required to select for each selection. We received sean_original_data.csv, sean_modifed_data.csv, natasha_original_data.csv, and natasha_modifed_data.csv which is the data from the colorblind person who used the original and new interfaces, and the data from the non-colorblind person who used the original and new interfaces.

Figure 4: Original Interface

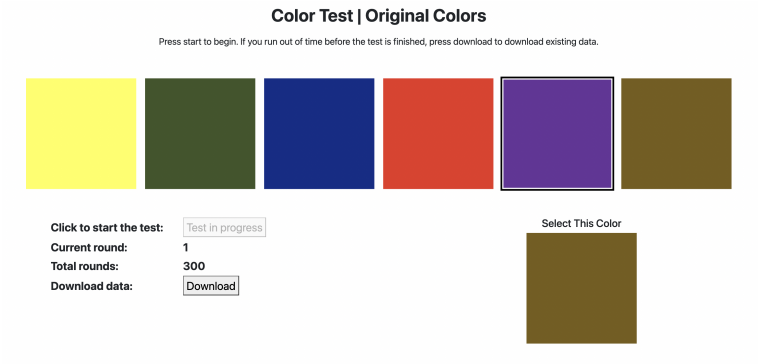


Figure 5: New Interface

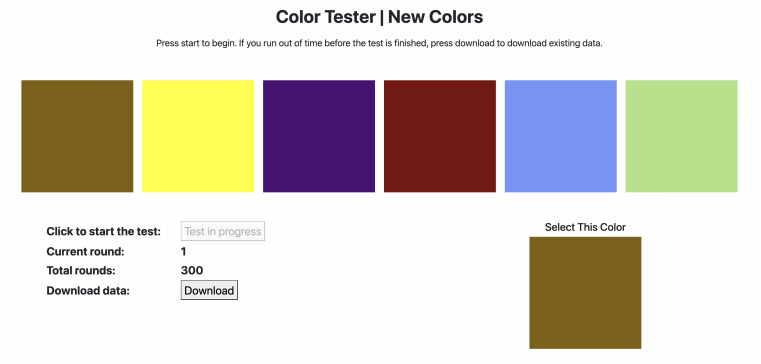


Figure 6: CSV Data Example

	A	B	C	D	E	F	G	H	I	J
1	1	2	3	4	5	6	answer	selected	duration	is correct
2	Yellow	Green	Blue	Red	Purple	Brown	Brown	Green	21274	FALSE
3	Purple	Blue	Brown	Red	Green	Yellow	Blue	Blue	138	TRUE
4	Purple	Brown	Yellow	Red	Blue	Green	Blue	Brown	142	FALSE
5	Red	Brown	Purple	Blue	Green	Yellow	Brown	Brown	138	TRUE
6	Purple	Green	Brown	Red	Yellow	Blue	Red	Green	127	FALSE
7	Brown	Green	Yellow	Purple	Red	Blue	Brown	Green	142	FALSE
8	Brown	Green	Yellow	Blue	Red	Purple	Yellow	Green	129	FALSE
9	Green	Blue	Red	Purple	Yellow	Brown	Green	Blue	128	FALSE
10	Blue	Purple	Green	Brown	Red	Yellow	Brown	Purple	138	FALSE
11	Green	Blue	Purple	Yellow	Red	Brown	Green	Blue	141	FALSE
12	Brown	Purple	Yellow	Red	Blue	Green	Yellow	Purple	147	FALSE
13	Green	Yellow	Purple	Brown	Blue	Red	Green	Yellow	134	FALSE
14	Purple	Red	Brown	Yellow	Green	Blue	Blue	Red	270	FALSE
15	Brown	Blue	Green	Yellow	Purple	Red	Green	Blue	147	FALSE
16	Yellow	Red	Blue	Purple	Brown	Green	Blue	Red	130	FALSE
17	Red	Yellow	Purple	Brown	Blue	Green	Brown	Yellow	139	FALSE
18	Green	Brown	Red	Purple	Blue	Yellow	Purple	Brown	134	FALSE
19	Red	Brown	Yellow	Blue	Purple	Green	Purple	Brown	141	FALSE
20	Blue	Green	Purple	Red	Yellow	Brown	Red	Green	135	FALSE
21	Yellow	Blue	Purple	Red	Green	Brown	Red	Blue	126	FALSE
22	Brown	Green	Purple	Blue	Red	Yellow	Brown	Green	228	FALSE
23	Brown	Purple	Yellow	Green	Red	Blue	Blue	Purple	166	FALSE
24	Brown	Green	Purple	Red	Blue	Yellow	Red	Green	163	FALSE
25	Brown	Red	Green	Yellow	Blue	Purple	Red	Red	293	TRUE
26	Purple	Yellow	Brown	Green	Blue	Red	Red	Yellow	304	FALSE
27	Purple	Red	Green	Brown	Blue	Yellow	Red	Red	174	TRUE
28	Green	Red	Blue	Brown	Purple	Yellow	Blue	Red	1469	FALSE
29	Brown	Purple	Blue	Yellow	Green	Red	Yellow	Purple	309	FALSE
30	Red	Purple	Blue	Green	Yellow	Brown	Red	Purple	273	FALSE
31	Purple	Blue	Yellow	Brown	Green	Red	Green	Blue	152	FALSE
32	Purple	Red	Yellow	Brown	Blue	Green	Green	Red	2082	FALSE
33	Green	Red	Purple	Yellow	Brown	Blue	Green	Red	135	FALSE

4 Results

The correctness results of the experiment can be seen in figure 7.

Figure 7: Correct Color Chosen

Correct : Incorrect	Color Blind Person	Non - Color Blind Person
Original Interface	53.0% 160 : 140	98.0% 294 : 6
New Interface	100.0% 300 : 0	99.9% 299 : 1

The average time to click results can be seen in figure 8.

Figure 8: Average Time to Click

Duration Average (sec)	Color Blind Person	Non - Color Blind Person
Original Interface	1.19	1.03
New Interface	1.21	0.96

5 Analysis

The new interface caused an 87.5% increase in correctness for the Color Blind Person, and a 1.7% increase in correctness for the Non-Color Blind Person. Furthermore, the new interface resulted in a 1.68% increase in average time to click for the Color Blind Person, and a 6.79% decrease in average time to click for the Non-Color Blind Person. However, the Color Blind Person took the original and new interface tests using different laptop orientations, which may have influenced the time to click results.

To determine what effect the new interface had on time to click, we test our null hypothesis.

H_0 : There is no difference in the average time to click between the new and original interfaces.

After running a t-test for the data pertaining to the Color Blind Person, we can not reject the null hypothesis as $p = 0.669$ is too large.

After running a t-test for the data pertaining to the Non-Color Blind Person, we can reject the null hypothesis as $p = 3.336 * 10^{-5}$ is very small.

We also analysed if the order of the colors had any effect on the correctness or time to click. Based on our need-finding interview and other research, we identified red/brown, brown/green, and purple/blue as confusing color combinations. This data is shown in figures 9, 10, and 11.

Figure 9: Correct Color Chosen by Color Blind Person When Confusing Color Combinations are Present

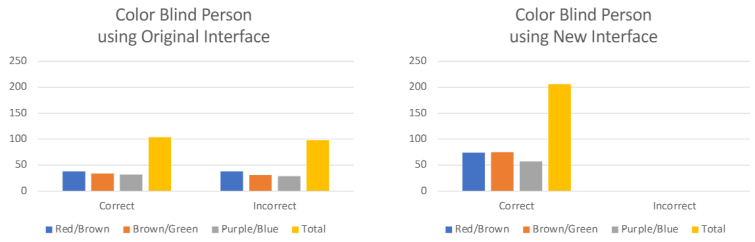


Figure 10: Correct Color Chosen by Non-Color Blind Person When Confusing Color Combinations are Present

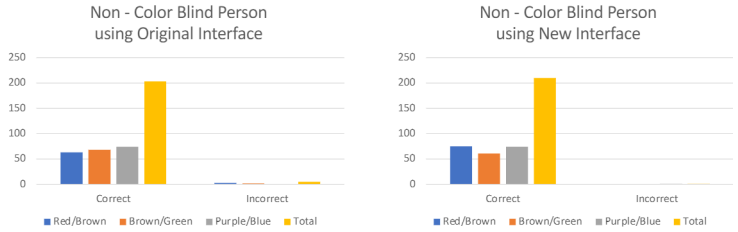


Figure 11: Average Time to Click When Confusing Color Combinations are Present

Duration Average (when the confusing colors are next to each other)	Color Blind Person	Non - Color Blind Person
Original Interface	1.21	1.03
New Interface	1.22	0.96

6 Conclusion

Given the 87.5% increase in correctness for the Color Blind Person and the 1.7% increase in correctness for the Non-Color Blind Person, we conclude that the new interface increases correctness relative to the original interface.

Given that we could not reject the null hypothesis with regards to time to click for the Color Blind Person but we could for the Non-Color Blind Person, we can not conclude the new interface reduces time to click.

Because there is almost no difference in average time to click between the overall data and the confusing color combination data, we can not conclude that the the order of colors has any effect on time to click.