LED/LCD Reaction Time With and Without Dissonance

By Ravi Varma, Amanda Cates, Avnish Sengupta, Lexi Scavetti, Ardo Nashalian,

and Maria Chamieh

Abstract

In this experiment we will be testing choice reaction time to various visual stimuli. While simple reaction time is the time taken to respond to a single stimulus, choice reaction time is the time taken to differentiate between multiple stimuli, and give the correct response. The stimuli will be divided into two categories with two situations: identifying color LED lights and identifying words of color on an LCD screen, with the colors and words either matching or differing. By implementing a circuit board along with Python and Arduino, colors will be randomly generated and we will then press the button associated with the given color, thereby recording the reaction time. The goal of this experiment is to compare choice reaction times of seeing a color and reading a word with and without distractions. Additionally, we will also be analyzing the data to draw conclusions as to which visual stimuli generated the fastest simple reaction time and choice reaction time. This data will then be quantified, histograms will be plotted, and a statistical t-test will be performed using Python software to determine the relevant factors that impact our data. Due to having to process reading a word, it is expected that choice reaction time will be longer when reading the word of color, compared to that of seeing a color LED light.

Introduction

Reaction time is a key evolutionary trait that all animals have. The ability to process external stimuli and react accordingly as quickly as possible is a much desired trait. Scientists have divided reaction times into two types: simple reaction times and choice reaction times. Simple reaction time, or SRT, consists of reacting to a singular input. Examples of this include pressing a button when a light flashes, or clicking a key when a trigger is shown. Choice reaction time, or CRT, consists of reacting appropriately to several different stimuli. Examples of this include pressing the correct button in response to its corresponding shapes, or performing the actions on a Bop-it. In our first experiment, we measured the SRT of our group members, while in this experiment we want to measure CRT.

Within this experiment the reaction times were measured for four different types of stimuli including LED only, LCD (word) only, LCD with a color dissonance, and an LED with a word dissonance. The goal was to better understand which stimulus, word, or color, is quickly picked up by the nervous system and reacted to. The results were then compared to one another by comparing the averages and confirming the data using a t-test. Python was used to generate histograms to get a better understanding of the trends of the reaction times.

Equipment

- LED Lights (Red, Blue, Green)
- Buttons
- Jumper wires
- Breadboard
- Uno R3 Controller Board with Expansion
- A power source (Laptop)
- LCD 1602 Module with pin header
- 10K Ohm Resistors

Methods

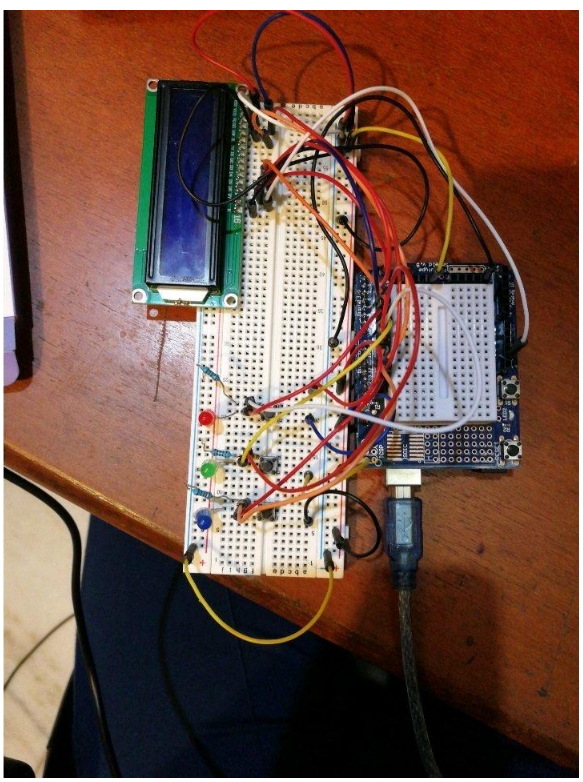

Figure 1: Experiment setup

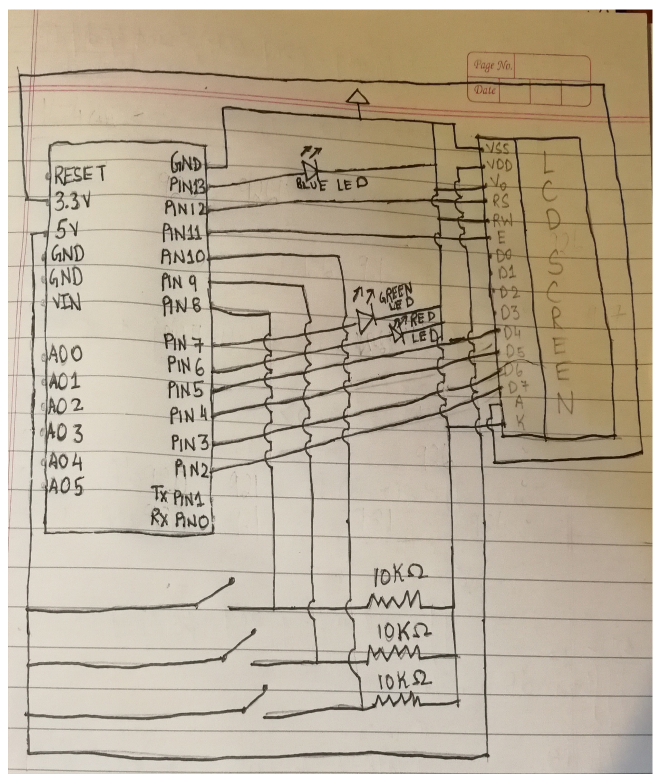

Figure 2: Experiment Circuit Schematic

The setup shown in Figure 1 circuit is framed in a way to provide different types of visual stimuli and document our reaction times. Connected to a breadboard is an LCD 1602 Module shown to the right of the schematic. The VCC pin, V_0 pin, RS (Register Select) pin, RW (Read/Write) pin, and the K or LED- negative pin of the LCD screen is connected to the Ground pin of the Arduino Uno as shown in Figure 2. The VDD pin is connected to the 5V Arduino pin. The A or LED+ positive pin is connected to the 3.3V Arduino pin. The D_4, D_5, D_6, D_7, and E (Enable) pins are connected to Digital Pins 5, 4, 3, 2, and 11 respectively. Additionally, there is a Red LED, a green LED, and a blue LED whose positive leads are connected to digital pins 6,7, and 13 on the Arduino and negative leads are connected to Ground. Similarly buttons that document our reaction time to the red, green, and blue LEDs are connected via 10k Ohm resistors to digital pins 8,9, and 10 on the Arduino respectively. The corresponding buttons for each LED is known to the participant. This setup along with the Arduino code is used to analyze four different datasets.

In the first case, we document the participant's Simple Reaction Time to any one of the three LEDs flashing in a randomized order with a randomized time of delay between 100-500 ms . The corresponding code for this setup is uploaded on the Arduino IDE, and the time between an LED flashes and the correct button is pressed is displayed on the serial monitor along with the color being reacted to.

In the second case, we collect the participant's Simple Reaction Time to a word displayed on the LCD screen in a random order with random times of delay between 100-500 ms. This word could be either Red, Blue or Green. Similar to the earlier case, the corresponding code for this setup is uploaded on the Arduino IDE, and the time between a word is displayed on the LCD Screen and the correct button is pressed is displayed on the serial monitor along with the word being reacted to.

In the remaining two cases, we introduce dissonance and measure the participant's Choice Reaction time to two different stimuli- words and colors. In the third case, the LCD screen displays the right word and the LEDs flash random colors to distract the user. Finally, in the fourth case, the LEDs flash the correct color to react to and the LCD screen flashes random words to distract the user. In both the cases, the code is uploaded on the Arduino IDE which then displays the Reaction Time of the user to identify and respond to the correct stimuli, with the stimuli mentioned on the Serial Monitor as well.

In each case, the setup is not changed as the code ignores the pins that are not being used but are still connected. In the first case, the corresponding code ignores the LCD Screen pins, in the second case, the corresponding code ignores the LED pins, and in the third and fourth case, all the pins are utilized.

For each of these cases, about 50 readings of reaction times were collected by different users of the same age group at two different periods of the day- morning before 11 AM and evening after 5 PM. Histograms of this data were then plotted using Python software. This data was then analysed by computing and comparing the averages of the reaction times of each case, of each color across different cases, and of the readings collected at different time periods. Finally, a T-test was carried out to measure the statistical significance of reaction times to LEDs flashing only to the LCD Screen displaying words only, LEDs flashing with a distraction and the LCD

Screen displaying words with a distraction, LEDs flashing with and without a distraction, and the LCD Screen displaying words with and without a distraction.

Results

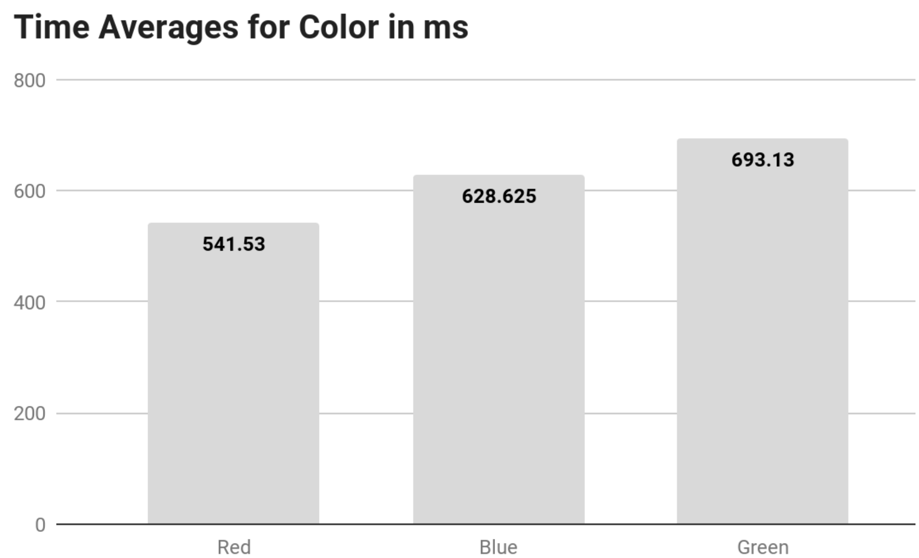

Figure 3: Bar Graph of Time Averages of Reaction Time to Different colored LEDs in the morning.

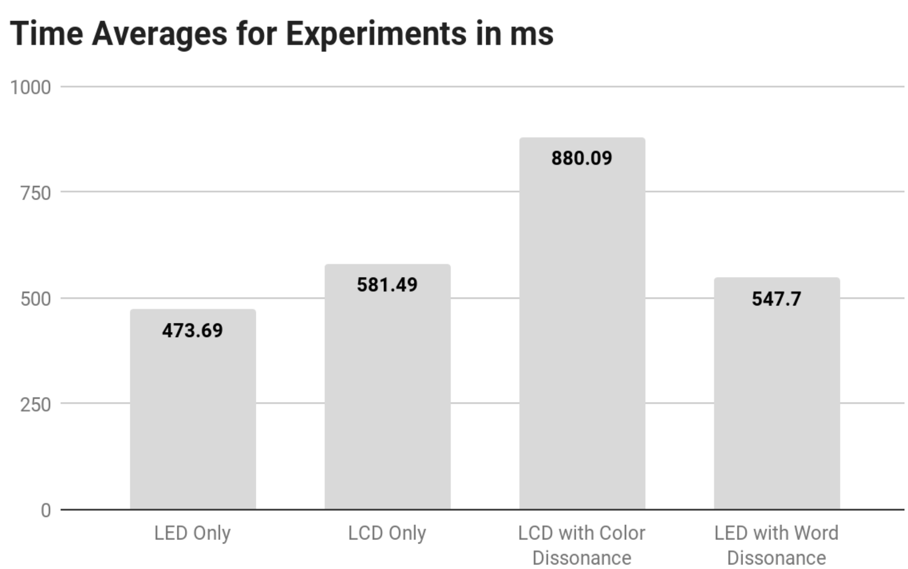

Figure 4: Bar Graph of Time Averages of Reaction Times to Different Visual Stimuli in the morning

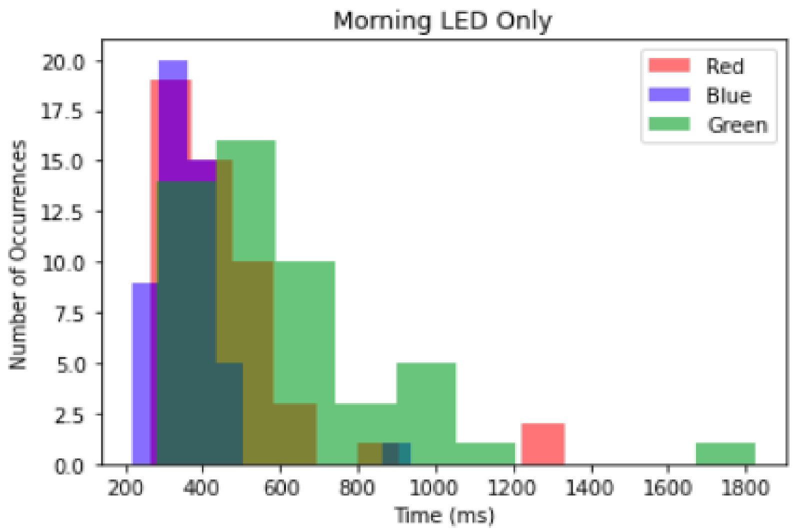

Figure 5: Histogram of the Reaction Times to Red, Blue and Green LEDs in the morning.

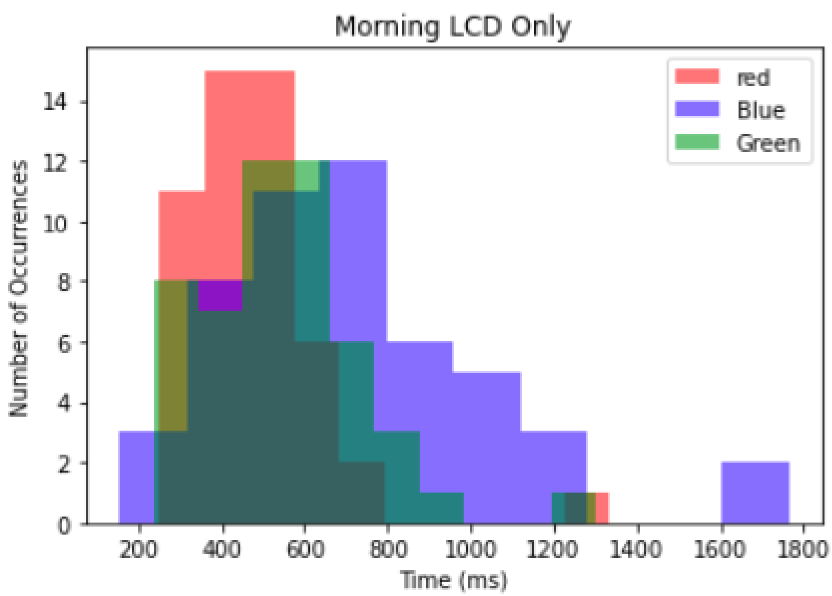

Figure 6: Histogram of the Reaction Times to Red, Blue and Green words in the morning.

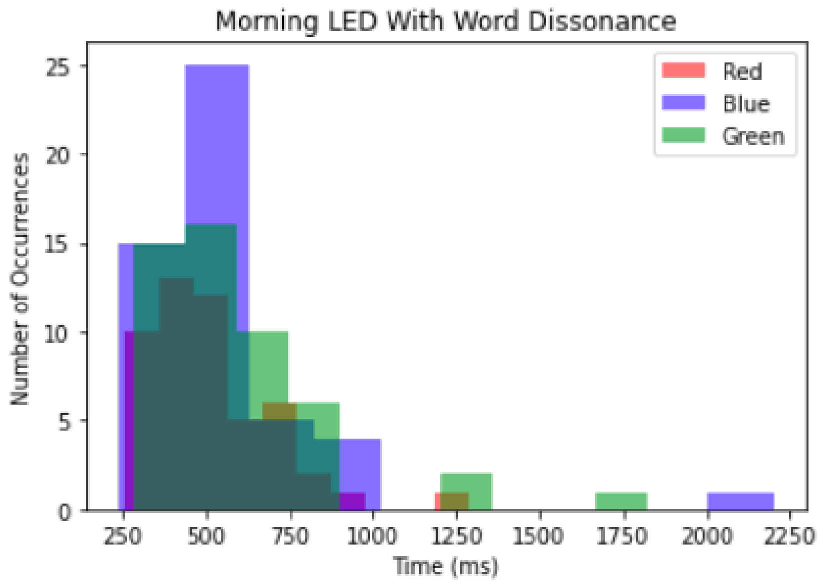

Figure 7: Histogram of Reaction Times to Red, Blue and Green LEDs with distraction from the LCD Screen in the morning

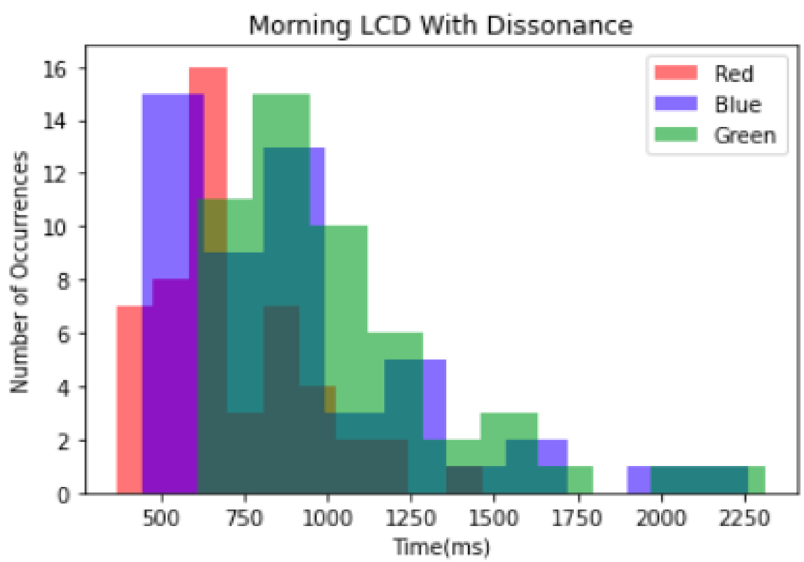

Figure 8: Histogram of Reaction Times to Red, Blue and Green words with distraction from the LEDs in the morning

	LEDs Only Standard Deviation (ms)	LCD Screen Only Standard Deviation (ms)	LEDs with word Dissonance Standard Deviation (ms)	LCD Screen with color dissonance Standard Deviation (ms)
Red	178.51	219.12	180.07	195.74
Blue	141.54	217.13	306.25	226.54
Green	302.07	264.88	184.23	281.41

Table 1: Standard Deviations of Each Color of the Datasets of Morning Data measured in ms.

	LEDs Only	LCD Screen Only	LEDs with word Dissonance	LCD Screen with color dissonance
LEDs Only		3.383e-07	0.007859	
LCD Screen Only				1.141e-09
LEDs with word Dissonance				7.361e-18
LCD Screen with color dissonance				

Table 2: P-values of Morning Data

The values of Standard Deviation for each stimuli in all the datasets are large in Table 1 since it is a collection of reaction times across different users, and readings due to human error or functional error were not removed from the raw data to not compromise the collected data. This skewed the distribution in the histogram shown in Figures 5, 6, 7, and 8 as values far from the mean of the data were taken into account.

The histograms in Figures 5, 6, and 7 consistently show the Red stimulus to be reaching its peak before that of Green and Blue stimuli, regardless of it being word or color. Based on the histograms in Figures 5, 6, 7, and 8, T-tests were performed comparing the data between all datasets in the morning except LEDs with word Dissonance versus LCD Screen Only and LCD Screen with Word Dissonance versus LEDs only since the factors involved in either dataset are extremely different to help us draw any helpful conclusions. The T-tests yielded p-values shown in Table 2 where all the p-values were found to be lower than 0.05, indicating that the datasets were statistically significant.

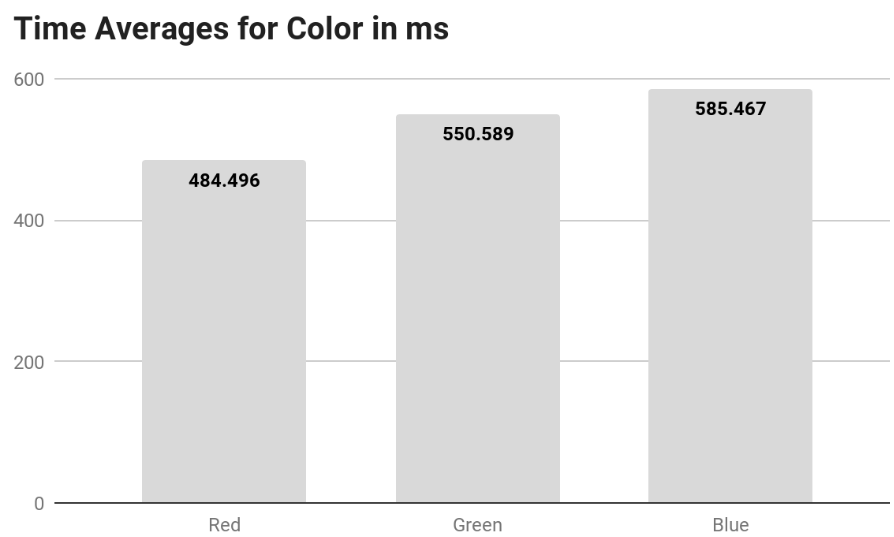

Figure 9: Bar Graph of Time Averages of Reaction Time to Different colored LEDs in the evening.

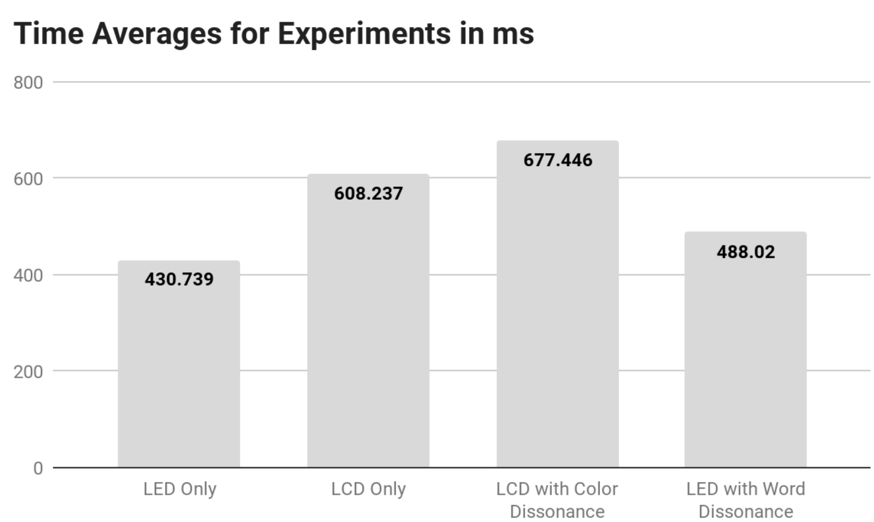

Figure 10: Bar Graph of Time Averages of Reaction Times to Different Visual Stimuli in the evening

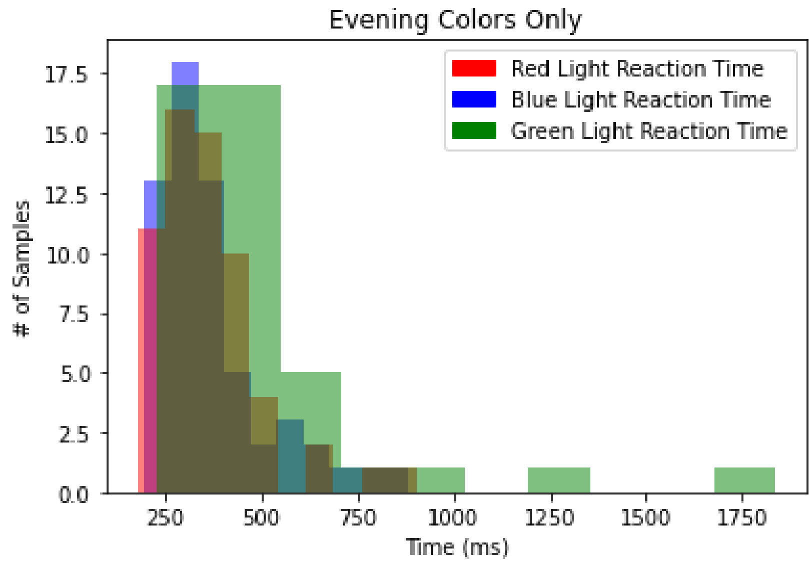

Figure 11: Histogram of the Reaction Times to Red, Blue and Green LEDs in the evening.

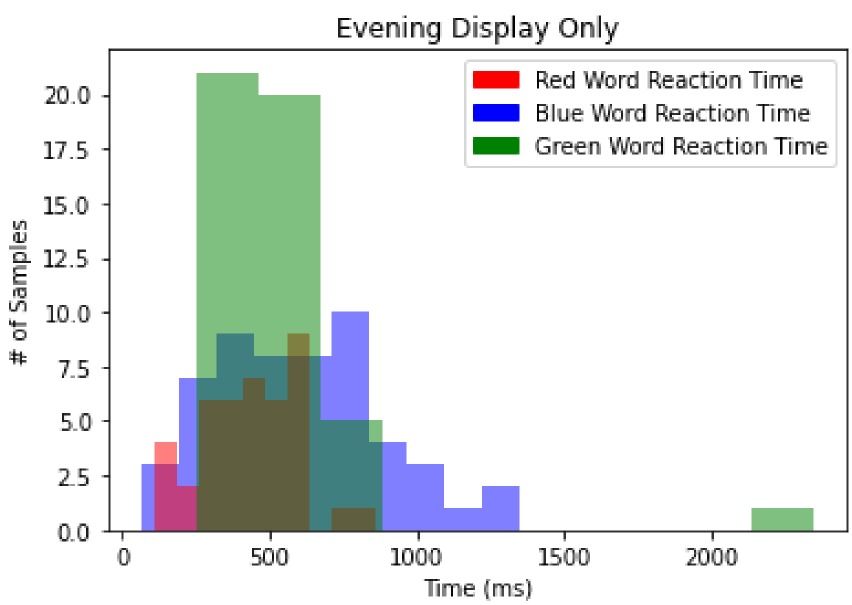

Figure 12: Histogram of the Reaction Times to Red, Blue and Green words in the evening.

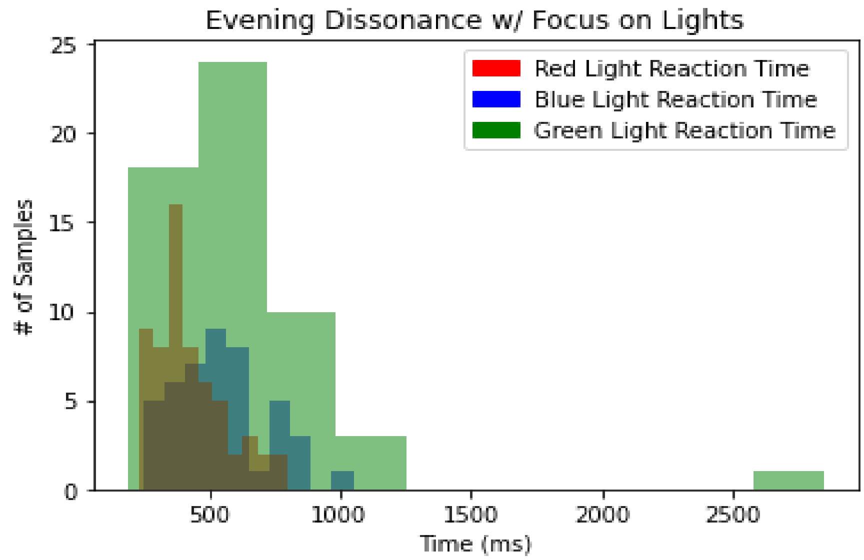

Figure 13: Histogram of Reaction Times to Red, Blue and Green LEDs with distraction from the LCD Screen in the evening.

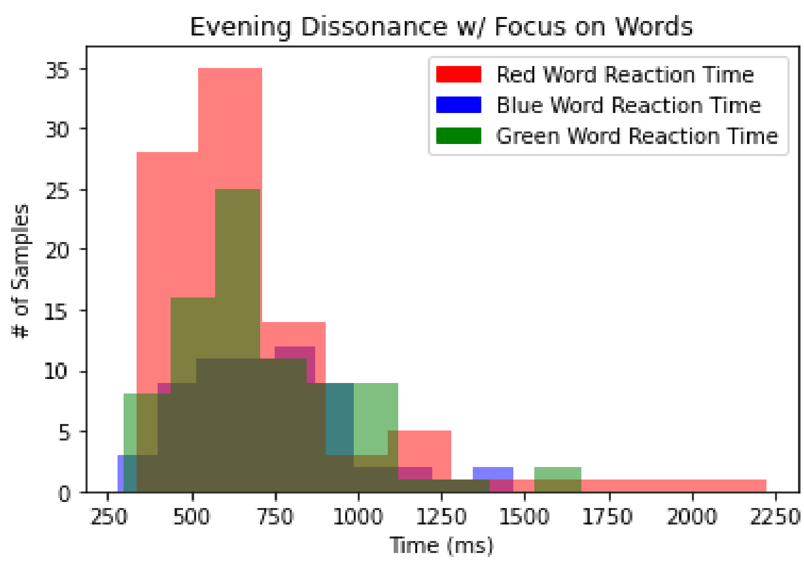

Figure 14: Histogram of Reaction Times to Red, Blue and Green words with distraction from the LEDs in the evening

	LEDs Only Standard Deviation (ms)	LCD Screen Only Standard Deviation (ms)	LEDs with word Dissonance Standard Deviation (ms)	LCD Screen with color dissonance Standard Deviation (ms)
Red	219.29	364.53	178.91	208.33
Blue	146.16	435.04	476.95	452.46
Green	381.96	565.06	377.61	309.87

Table 3: Standard Deviations of Each Color of the Datasets of Evening Data measured in ms.

	LEDs Only	LCD Screen Only	LEDs with word Dissonance	LCD Screen with color dissonance
LEDs Only		4.563e-07	0.198252	
LCD Screen Only				3.840e-09
LEDs with word Dissonance				3.115e-11
LCD Screen with color dissonance				

Table 4: P-values of the Evening data

The values of Standard Deviation for each stimuli in all the datasets are large in Table 3, due to the same reasons for the large Standard Deviation values in Table 1, which has skewed the distribution of the histogram in Figures 11, 12, 13, and 14. Since the histograms in Figure 11 and 13 seemed to have similar peaks and means, T-tests were performed to check if the data was statistically significant. In Table 2, the p-values of all datasets in the evening are recorded except LEDs with word Dissonance versus LCD Screen Only and LCD Screen with Word Dissonance versus LEDs only due to the same reason the T-tests of these datasets were not taken in the morning as their p-values would not aid us in our analysis at all. These p-values shown in Table 4 where all the p-values except LEDs only versus LEDs with Word Dissonance in the evening were found to be lower than 0.05, indicating that the datasets were statistically significant. Since, the p-value for the T-test comparing LEDs only with LEDs with Word Dissonance in the evening yielded a value higher than 0.05, it is statistically insignificant and no conclusions can be drawn about the data in this case.

Data analysis

Reaction time is the length of time taken for a person to respond to a given stimulus or event. It measures how long it takes the brain and nerves to react to the stimulus. We use quick reactions in our daily lives when driving, playing sports and in emergency situations.

Reaction time tests inform us about the state of our motor speed, our general alertness, and our cognitive processes so it is important to assess and check one's reaction time. Many factors can affect how fast we react such as age, gender, physical fitness, fatigue, distraction, alcohol, personality type, and whether the stimulus is auditory or visual.

We produced 4 choice reaction time tests to compare reaction times between LED colors and LCD words, with and without dissonance. Our hypothesis matches with our results. We found out that in both morning and evening results' the order of increasing reaction time goes as follows: LED only, LED with word dissonance, LCD only, LCD with color dissonance.

Specifically, for the morning results, their orders of magnitude were respectively 473.69ms, 547.7ms, 581.49ms, 880.09 ms as shown in Figure 4. As for the evening results, they were respectively 430.739ms, 488.03ms, 608.237ms, 677.446ms as shown in Figure 10.

LCD tests yield slower reaction times because you must read then process and connect the word to the button placed near its represented color. This requires an additional cognitive step which the LED test does not require. The LED test only relies on processing the visual stimuli and pressing the button placed near the LED which just flashed.

The LCD and LED tests' reaction time proved to be faster when there wasn't dissonance. The mismatched words and mismatched colors proved to be a distraction in the LCD test and the LED test respectively, adding more time to the reaction time. However, it must be noted that the LED with dissonance's performance was close to the LED test without dissonance.

In both the morning results and the evening results, the average reaction time to the red LED or LCD word was higher than that of the green or blue LED or LCD word. For the evening results, we found that the average reaction time to red is 484.496ms, which is 66ms earlier than the average reaction reaction time to blue (550.589ms) and 101ms earlier than the average reaction time to green (585.467ms). For the morning results, we found that the average reaction time to red is 541.53ms, which is 87ms earlier than the average reaction reaction time to blue (628.625ms) and 151ms earlier than the average reaction time to green (693.13ms).

The color red yields a faster reaction time for the LCD tests because it has the least number of letters (3) —versus the others colors who have 4 letters, blue, or 5 letters, green.

For the LED tests, professor of psychology at the University of Rochester, Andrew Elliot, researcher in the field of color psychology, studied the reaction time of humans when seeing different colors and found that when humans see red, their reaction time is much faster in comparison to other colors. He explains that humans are more alert of such a color because it is a danger cue, which entails the necessity of a fast reaction time. It screams urgency and emergency. The reason red has such an effect on us is because our ancestors have learned to stay away from bright colors in nature, namely red, because they inform that the plant or animal has a defense mechanism, and posits a survival threat if approached.

We found that the majority of the morning reaction tests' times in Figure 3 are slower than the evening ones shown in Figure 9. Evening LED only reaction time (430.739ms) is faster by 43ms than its morning counterpart(473.69ms). Evening LCD with color dissonance reaction time (677.446ms) is faster by 203ms than its morning counterpart (880.09ms). Evening LED with word dissonance reaction time (488.02ms) is faster by 60ms than its morning counterpart (547.7ms).

Our results agree with Daniel Bratzke's results at the University of Tuebingen. He explains why our reaction time is slow in the morning, or more generally, why the time of day affects our cognitive abilities. In the early morning, it takes longer to detect and identify a visual stimulus because of our tired state. He theorized that this is due to our circadian rhythm, which reaches a low point in the morning and peak in the late evening. Indeed, central processing slows down during the night so you wake up with limited cognitive abilities, and have lower reaction times in contrast to your elevated performance at night.

Discussion

7 out of 8 p-values calculated were statistically significant, with a p-value less than 0.05. Since they were smaller than 0.05, we can safely reject our null hypothesis and say that there is a difference between reacting to words versus colors. This confirms that there is a meaningful difference in choice reaction times and that any difference was not coincidental. The smaller the p-value, the more significant the difference in times is. It was found that with the smallest p-value, LED with dissonance vs. LCD with dissonance had the most significant difference, followed by LCD only vs. LCD with dissonance, LED only vs. LCD only, and finally LED only vs. LED with dissonance having the largest p-value and the least significant difference. From comparing the p-values to the average reaction times, we found that adding dissonance had a greater effect on the LCD choice reaction time compared to the LED choice reaction time, color dissonance had substantially slowed down the LCD choice reaction time, reading words substantially slowed down the choice reaction time compared to seeing color, and word dissonance only slightly slowed down LED choice reaction time, if at all. This last finding is where the 8^{th} statistically insignificant p-value falls under.

Conclusion

To conclude, our hypothesis was correct, with dissonance and reading both slowing down reaction times. Our expected fastest to slowest reaction times were also correct, with LED only producing the fastest reaction time, followed by LED with dissonance, LCD only, and LCD with dissonance producing the slowest reaction time. The LED alone produced the fastest reaction time, having neither dissonance nor reading involved. The LCD with dissonance produced the slowest reaction time, having both dissonance and reading involved. Color also proved to be a factor in choice reaction time, with the red LED generating the fastest reaction time, followed closely by the blue LED, and the green LED generating the slowest reaction time. Error within this experiment could have been due to one LED color randomly being more prevalent than the other colors, skewing the average choice reaction time data. Error could have also been found in inconsistent reaction times due to human error, skewing the average choice reaction time data. These choice reaction time results can be used to show why we use traffic lights instead of traffic symbols, as well as flares as a means of communicating danger during war. These results also demonstrate how easily minor variables can affect choice reaction time, indicating how imperative it is to study choice reaction time within occupations such as pilots, drivers, and doctors, among many others.

In the future, this choice reaction time experiment could be improved by adding more colors and words. The experiment could be repeated with a greater number of variables to determine whether this has an effect on the order of choice reaction times in this experiment, fastest reaction time to slowest reaction time. Additionally, by adding more variables the data could then be compared based on the number of variables, e.g. 3 colors and words vs. 4 colors and words vs. 5 colors and words, and so on. While logically, a greater number of variables should slow down reaction time due to more memorization, it could then be determined to what extent the number of variables affects the choice reaction time of each section of this experiment. As seen in in the academic paper, “Spatial Compatibility and Anatomical Factors in Simple and Choice Reaction Time,” this experiment could also be improved by comparing choice reaction times from dominant and nondominant hands as well as varied hand positions, to see if hand mobility affects choice reaction time (Anzola, Bertoloni, Buchtel & Rizzolatti, 1977). Another idea to further this experiment comes from researcher E. E. Smith, who suggests comparing only one individual’s choice reaction times, but comparing the first attempt’s choice reaction time to a later attempt only after practicing at reacting to the experiment (1968). This experiment idea could then determine if increased familiarity and expectation could affect choice reaction time.

References

Anzola, G., Bertoloni, G., Buchtel, H., & Rizzolatti, G. (1977). Spatial compatibility and anatomical factors in simple and choice reaction time. *Neuropsychologia, 15*(2), 295-302. doi:10.1016/0028-3932(77)90038-0

Smith, E. E. (1968). Choice reaction time: An analysis of the major theoretical positions. *Psychological Bulletin, 69*(2), 77-110. doi:10.1037/h0020189