20S-PHYSICS 4AL-12 Unit 1 report

CHARLES XIAN ZHANG, RYAN ROSSMANGO, Brendan M Rossmango, CLAIRE CHUNG, Neil Vaishampayan

TOTAL POINTS

47.5 / 50

QUESTION 1

1 Names, Title, Abstract 5 / 5

✓ **- 0 pts** Correct

QUESTION 2

2 Introduction 7.5 / 8

+ **8 pts** Excellent
✓ + **7 pts** Good
+ **6 pts** Sufficient
+ **5 pts** Needs improvement
+ **0.5 Point adjustment**

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3 precedent?

QUESTION 3

3 Methods 9 / 10

+ **10 pts** Excellent
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4 A schematic of the setup would be a nice addition

QUESTION 4

4 Results 14 / 15

+ **15 pts** Excellent
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QUESTION 5

5 Conclusion 8 / 8

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7 Write this as 0.1672. This does show some difference between the data sets, just not at the 0.05 confidence level.

QUESTION 6

6 References 4 / 4

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Reaction Times to Various Stimuli

Claire Chung, Brendan Rossmango, Ryan Rossmango, Neil Vaishampayan, Charles Zhang
Physics 4AL, Lab 12, Group 2
April 19, 2020

Abstract

This experiment examined the differences in reaction times for various types of stimuli, notably between auditory and visual stimuli. Additionally, experiments with various stimuli, and thus various decisions to make, also took place. Though similar experiments have been tested before, our focus was to find if varying predictability of LED flashes (through differing delay periods) would have a significant difference on reaction times. The hypothesis was that less predictability would increase reaction times and more predictability would decrease reaction times. Predictability was defined by the maximum range of delay between LED flashes, as smaller ranges would output a generally consistent delay time and larger ranges could output inconsistently spread delay times.

The results showed that buzzer reaction times were actually slower than LED reaction times rather than faster as predicted, but at an insignificant level. This did not confirm the alternative hypothesis either and suggested that there is too much variance between subjects to draw a direct conclusion in either direction. Moreover, as more choices were presented, and the cognition required increased, the time to react to a several-stimulus setup increased. Finally, the results of the predictability tests showed that higher predictability of the LED flashes causes significantly faster reaction times, as was hypothesized.

Introduction

Reaction time is most simply defined as the time between the presentation of a stimulus and a response to that stimulus. Simple reaction time tests measure the period of time between a single stimulus and a single response, while choice reaction time tests measure the period of time between multiple stimuli and responses (Jain, 2015).

These trials involved the use of buzzers and varying colors of LEDs as stimuli, and the pressing of buttons as a response. By utilizing circuit components to randomly present these stimuli and an Arduino to measure the time between presentation and response, reaction times were measured in both simple reaction and choice reaction scenarios.

Prior reaction time experiments suggest that the simple auditory reaction time is shorter than the simple visual reaction time by approximately 30 milliseconds (Jain, 2015). Experimentation also places the average simple reaction time of test subjects in the 18-24 age group at 217.9 milliseconds (Woods, 2015). Based on precedence, it is expected that tests utilizing the buzzer will result in a significantly lower mean reaction time than those involving recognition of an LED. The null hypothesis, which we do not expect, is that there will be no significant difference between reaction times to the visual stimulus and to the auditory stimulus.

Meanwhile, choice reaction time tests convey that the average time for the 18-24 age group is approximately 450-500 milliseconds, much longer than simple reaction times (Woods, 2015). Common sense confirms this notion, as the process of recognizing the presence of a stimulus, identifying the specific type of stimulus, and deciding the correct reaction is far more complex than a simple recognition and reaction. As a result, it is expected that the trials involving decision-making will produce significantly higher reaction times.

Further research was conducted to explore the relationship between decision-making, predictability, and reaction times. It is hypothesized that higher predictability would allow a person to react more quickly, while lower predictability would fluster a person, elongating the cognitive processes that go into decision-making and thus causing larger reaction times.

Method

The first experiment revolved around the difference between reaction times to a simple sound and light stimulus. A single red LED was connected to a button and Arduino. As the test ran, the Arduino would randomly flash the LED and measure the time between the LED's flash and the subject pressing the button. All subjects recorded approximately 100 trials of this test, and then the same process was repeated with a buzzer in place of the LED.

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Additionally, another version of the test targeted the variation in reaction times that occurred when the subject was presented with more choices at once. A single RGB LED was connected to three different buttons and an Arduino. The Arduino would randomly display either red, green, or blue at random time intervals, and the subject would have to press the correct button based on the color displayed. Using the same process as the first experiment, the reaction times were recorded for this test, as well as a test that utilized only two colors.

A final version of the experiment investigated the impact of varying predictability, operationally defined as the range of possible delay times between successive LED flashes. For example, high predictability would mean a short range of possible delays. Using the same setup as the 3 LED setup to keep the same need for decision-making, the Arduino's code was changed to model varying delay ranges between trials. The subject had to respond to light flashes with a very wide range of downtime in between flashes, a very small range of short downtime, and a very small range of long downtime. These results were then compared to the results of the original delay range from experiment two.

The analysis was performed by aggregating the data between all five test subjects for the auditory versus visual experiment and using Python to plot it as a histogram separated into 25 bins. From this data, means, standard deviations, and T-tests were evaluated. The same process was performed on the results of the experiments with the added variable of choice, without aggregating the data.

Results

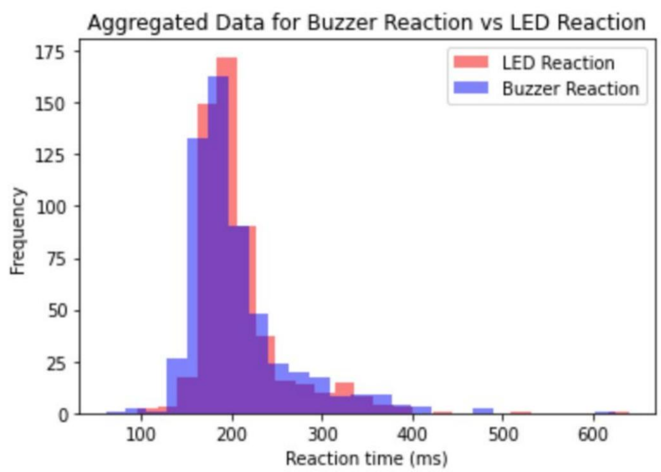

Figure 1: Histogram of the Aggregated Data Comparison between LED and Buzzer Reaction Times

	Mean (ms)	Standard Deviation (ms)
Aggregated LED Samples	209.04	51.78
Aggregated Buzzer Samples	205.85	57.88

Table 1: Mean and Standard Deviation of the Aggregated Data

Here we observe that the means of the Aggregated LED samples and the Aggregated Buzzer Samples are very close together, so we will need to check the p-values to confirm or refute our hypothesis.

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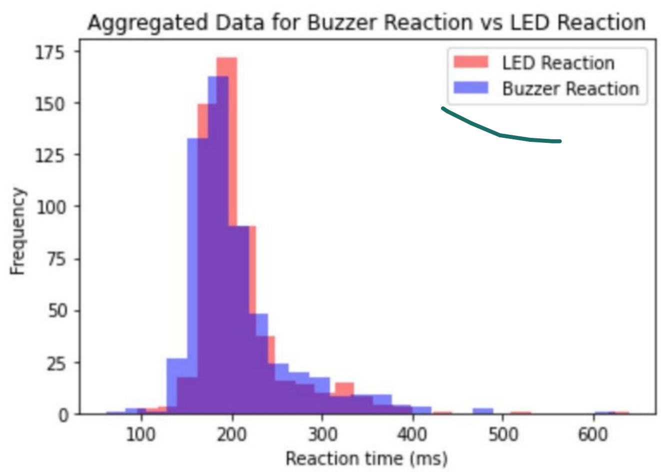

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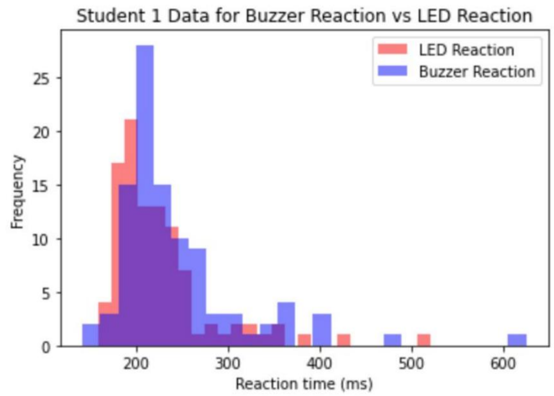

Figure 2: Histogram of comparison within a single sample collected by Student 1

	Mean (ms)	Standard Deviation (ms)
LED: Student 1	226.17	57.46
Buzzer: Student 1	243.83	70.91

Table 2: Mean and Standard Deviation for Student 1 data

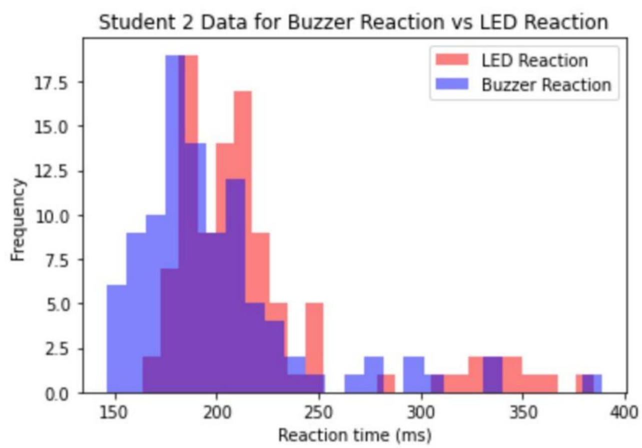

Figure 3: Histogram of comparison within a single sample collected by Student 2

	Mean (ms)	Standard Deviation (ms)
LED: Student 2	220.16	47.42
Buzzer: Student 2	199.76	41.73

Table 3: Mean and Standard Deviation for Student 2 data

Here we see two examples of the individual data, where Student 1 has a higher mean for LED trials than for the Buzzer trials, while Student 2 has the opposite. Inconsistencies like this might have contributed to the means in the aggregate data to be so close.

	T-Value	P-Value	Degrees of Freedom
Aggregate Data	0.9658	0.1672	1103
Student 1	-1.9350	0.9721	99

Student 2	3.2295	0.0008	99

Table 4: Degrees of Freedom, T- and P-Values of Data with an alpha value of 0.05

As we can see, the only data with a significant p-value is Student 2's data.

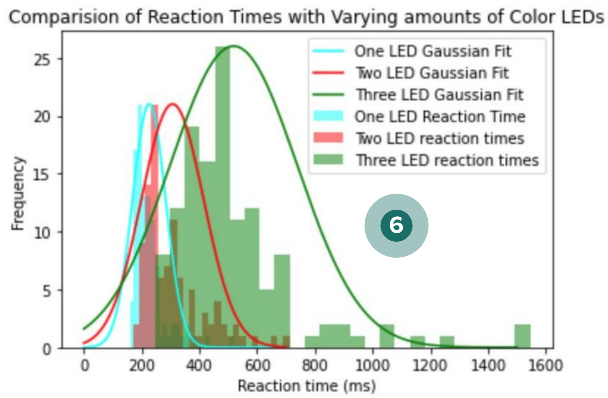

Figure 4: Histogram of comparison between different amounts of colors in the trials

	Mean (ms)	Standard Deviation (ms)
One LED Sample	226.17	57.46
Two LED Sample	307.19	108.05
Three LED Sample	518.61	219.53

Table 5: Mean and Standard Deviation for Single Sample Colors Trial

Here we observe that the mean reaction time increases as the amount of colors possible increases.

	T-Value	P-Value	Degrees of Freedom
1 vs 2 LEDs	15.2169	<0.00001	1023
1 vs 3 LEDs	29.9319	<0.00001	1033
2 vs 3 LEDs	19.0078	<0.0001	972

Table 6: Degrees of Freedom, T- and P-Values with an alpha value of 0.05

All the p-values suggest statistical significance.

Individual Data:

	Buzzer	1 LED	2 LED	3 LED
Neil	243.83	226.17	307.19	518.61
Ryan	190.02	187.43	293.4	407.5
Charles	211.14	226.09	359.70	467.49
Brendan	190.3	188.3	290.1	362.95

Claire	199.76	220.16	473.3	511.17

Table 7a: Individual Means for all Trials

	Buzzer	1 LED	2 LED	3 LED
Neil	70.91	57.46	108.05	219.53
Ryan	43.58	32.56	109.2	138.1
Charles	65.48	61.69	87.00	145.43
Brendan	46.0	37.9	70.5	95.35
Claire	41.73	47.42	152.79	192.48

Table 7b: Individual Standard Deviations for all Trials

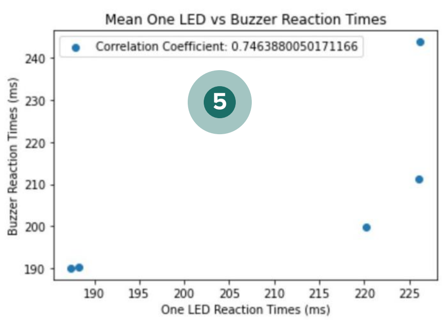

Figure 6a: Scatter plot of Individual Single Color LED and Buzzer Means

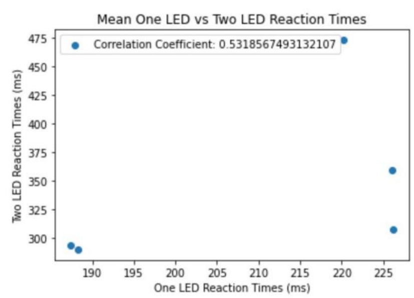

Figure 6b: Scatter plot of Individual Single Color LED and Double Color LED Means

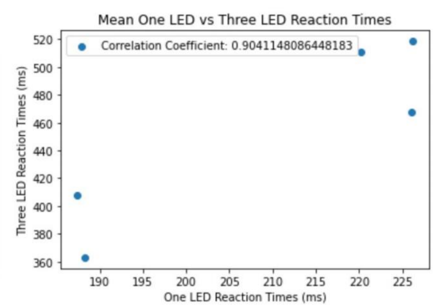

Figure 6c: Scatter plot of Individual Single Color LED and Triple Color LED Means

Further Research:

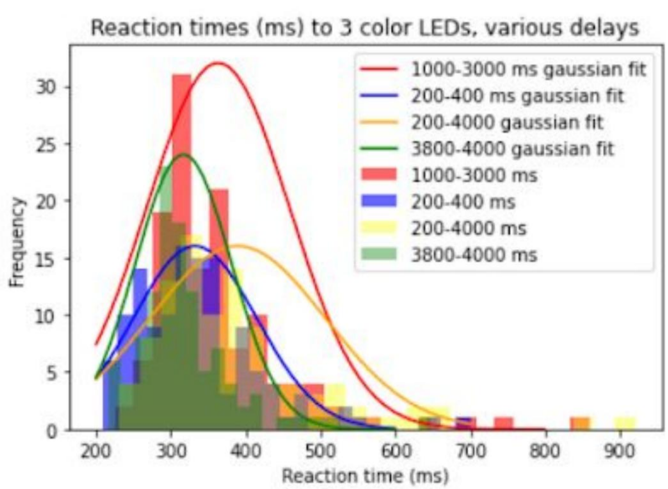

Figure 8: Histogram of Student 3's trials for Various Delays

Length of Delay (ms)	Mean (ms)	Standard Deviation (ms)	Number of Trials
Control: 1000-3000	362.94	95.35	130

Short, predictable: 200-400	332.14	82.36	125
Long, predictable: 3800-4000	316.7	64.07	110
Unpredictable: 200-4000	388.88	117.35	100

Table 8: Mean and Standard Deviation for Student 3' trials of Various Delays

Length of Delay comparisons (ms)	T-Value	P-Value	Degrees of Freedom
1000-3000 vs. 200-400	2.7554	0.0063	253
1000-3000 vs. 3800-4000	4.3259	0.0001	238
1000-3000 vs. 200-4000	1.8491	0.0657	228
200-400 vs. 3800-4000	1.5886	0.1135	233
200-400 vs. 200-4000	4.2533	0.0001	223
3800-4000 vs. 200-4000	5.5989	0.0001	218

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Conclusion

The aggregate data of reaction times to an LED and a buzzer (p-value of .1672) does not support the alternative hypothesis, which stated that people would react more quickly to an auditory stimulus than to a visual one. This failure to support the hypothesis can be explained by confounding variables such as distractions, and more importantly, inconsistencies between different subjects. The scatter plots and tables above elucidate that reaction times vary by person, and that one person's reaction patterns are similar throughout each experiment (moderately strong correlation coefficients, people are in the same area on the scatter plot throughout experiments).

Individual data demonstrates that three of the five subjects experienced smaller means for LED reaction times than for buzzer reaction times, opposite of what would be expected given previous studies. Student 1 in particular had a significant difference between reaction times, but the p-value associated with this data was .9721, because its significance corroborates the exact opposite hypothesis. Nonetheless, two students had statistically significant data relevant to our hypothesis; specifically Student 2's reaction time to a buzzer was indeed significantly lower than to an LED, with a p-value of 0.0008. Overall, for the reaction times to sound versus light, there is more evidence suggesting that people have different reaction capabilities, in that only two of five subjects reflected earlier findings.

However, data collected from the experiments involving choice tells an expected result, across all subjects - forcing people to make a choice while in the process of reacting drastically increases reaction times. Data was not aggregated for this portion of research, because all subjects reflected the same pattern, rising mean reaction times as more LEDs were added and more choices presented. A sample student's data exhibits a significant difference between reaction times to 1, 2, and 3 LEDs, with p-values all below 0.0001. There is also more variance within reaction times for each person, as indicated by the standard deviations increasing along with the number of LEDs. Thus, with more choices presented, the time to react to different stimuli will be longer and more varied, because more cognition and commitment are necessitated.

Lastly, results from the final experiment again support what was hypothesized, that in reacting to several stimuli, more predictability allows for faster reactions. A sample student performed the quickest to the LEDs that flashed at predictable moments, with means of 332.14 ms to the short 200-400 ms delay and 316.7 ms to the long 3800-4000 delay. These reaction times were significantly lower (p-values of 0.0001) than the mean reaction time to a stimulus with unpredictable delay - 388.88 ms (with a notably larger standard deviation of 117.35 ms) to respond to a delay that varied from 200-4000 ms. Additionally, the reactions to the highly predictable delay were significantly faster than those to the moderate delay (p-values of 0.0063 and 0.0001). Reaction times between the short and long, predictable delays were not significantly different (p-value of 0.1135), but this feat only elucidates the more influential factor: predictability. With higher predictability, less time is devoted to thinking about when the LED will flash; a person can prepare oneself to press the button at the correct moment with a predictable delay. In fact, with the short delay, no time is spent thinking at all, reactions just happen naturally. With an unpredictable delay, it is much more difficult to prepare oneself; a person will try to anticipate when the stimulus will transpire, but in reality the LED flashes at indeterminable moments, so a person's own thinking is delayed when the flash does occur.

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1000-3000 vs. 200-400	2.7554	0.0063	253
1000-3000 vs. 3800-4000	4.3259	0.0001	238
1000-3000 vs. 200-4000	1.8491	0.0657	228
200-400 vs. 3800-4000	1.5886	0.1135	233
200-400 vs. 200-4000	4.2533	0.0001	223
3800-4000 vs. 200-4000	5.5989	0.0001	218

Table 9: P-values for Student 3's trials of Various Delays

Conclusion

The aggregate data of reaction times to an LED and a buzzer (p-value of .1672) does not support the alternative hypothesis, which stated that people would react more quickly to an auditory stimulus than to a visual one. This failure to support the hypothesis can be explained by confounding variables such as distractions, and more importantly, inconsistencies between different subjects. The scatter plots and tables above elucidate that reaction times vary by person, and that one person's reaction patterns are similar throughout each experiment (moderately strong correlation coefficients, people are in the same area on the scatter plot throughout experiments).

Individual data demonstrates that three of the five subjects experienced smaller means for LED reaction times than for buzzer reaction times, opposite of what would be expected given previous studies. Student 1 in particular had a significant difference between reaction times, but the p-value associated with this data was .9721, because its significance corroborates the exact opposite hypothesis. Nonetheless, two students had statistically significant data relevant to our hypothesis; specifically Student 2's reaction time to a buzzer was indeed significantly lower than to an LED, with a p-value of 0.0008. Overall, for the reaction times to sound versus light, there is more evidence suggesting that people have different reaction capabilities, in that only two of five subjects reflected earlier findings.

However, data collected from the experiments involving choice tells an expected result, across all subjects - forcing people to make a choice while in the process of reacting drastically increases reaction times. Data was not aggregated for this portion of research, because all subjects reflected the same pattern, rising mean reaction times as more LEDs were added and more choices presented. A sample student's data exhibits a significant difference between reaction times to 1, 2, and 3 LEDs, with p-values all below 0.0001. There is also more variance within reaction times for each person, as indicated by the standard deviations increasing along with the number of LEDs. Thus, with more choices presented, the time to react to different stimuli will be longer and more varied, because more cognition and commitment are necessitated.

Lastly, results from the final experiment again support what was hypothesized, that in reacting to several stimuli, more predictability allows for faster reactions. A sample student performed the quickest to the LEDs that flashed at predictable moments, with means of 332.14 ms to the short 200-400 ms delay and 316.7 ms to the long 3800-4000 delay. These reaction times were significantly lower (p-values of 0.0001) than the mean reaction time to a stimulus with unpredictable delay - 388.88 ms (with a notably larger standard deviation of 117.35 ms) to respond to a delay that varied from 200-4000 ms. Additionally, the reactions to the highly predictable delay were significantly faster than those to the moderate delay (p-values of 0.0063 and 0.0001). Reaction times between the short and long, predictable delays were not significantly different (p-value of 0.1135), but this feat only elucidates the more influential factor: predictability. With higher predictability, less time is devoted to thinking about when the LED will flash; a person can prepare oneself to press the button at the correct moment with a predictable delay. In fact, with the short delay, no time is spent thinking at all, reactions just happen naturally. With an unpredictable delay, it is much more difficult to prepare oneself; a person will try to anticipate when the stimulus will transpire, but in reality the LED flashes at indeterminable moments, so a person's own thinking is delayed when the flash does occur.

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