Team #501

BE 312 Spring 2021 Lab 1, Reaction Times

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Abstract

For this lab, reaction time data was collected using a headset and a button. The test subject would wear the headset and then hit the button when they heard the noise. We used a Biopac program to record the time the noise was played and the time the button was pressed. This time difference is the reaction time, which is used for most of the analysis in this lab. The reaction time allowed us to find the voltage threshold for the button to register. We also calculated the average and standard deviation of the reaction time for various groups, such as male vs female. Creating confidence intervals helped us to compare these averages. We found that there is a significant difference in reaction time between gender, dominant and non-dominant hand, with a small difference between gamer and non-gamer.

Reaction Time Data

Question #1

We calculated the mean and standard deviation of the reaction times using excel formulas. Using the =AVERAGE function, all reaction times were averaged out to a value of .225 seconds. Similarly, using the =STDEV function allowed us to calculate the standard deviation of this same data set, whose value came out to .081 seconds.

From this data, we also calculated the 95% and 99.7% confidence intervals for both the pseudo-random and set interval data sets independent of each other. The 99.7% confidence interval is representative of a ±3 standard deviation range.

Using the pseudo-random data set, we found an average reaction time of .245 seconds and a standard deviation of .075 seconds. Our confidence interval was found by adding our average to the product of the z-score and error, as seen below.

$$C.I. = x \pm (z * (S_x) \ / \ Error)$$

$$Error \ = \ Standard\ deviation / sqrt(n)$$

The confidence interval variable x represents the average, z represents the z-score of the confidence interval, and Sx represents standard deviation. The value n represents the number of datapoints. Because each dataset has 35 people with 20 points each, so n is equal to 700. This value plugged into the error formula gave us an error of .00285. At a confidence interval of 95%, a z-score of 1.96 was used. At a confidence interval of 99.7, a z-score of 2.96 was used. These confidence intervals were calculated with the formula seen above.

$Pseudorandom\ 95\%\ C.I.\ =\ .245 \pm 1.96(.0753)/.00285$
$Pseudorandom\ 95\%\ C.I.\ range\ is\ from\ .240\ to\ .251$

$Pseudorandom\ 99.7\%\ C.I.\ =\ .245 \pm 2.96(.0753)/.00285$
$Pseudorandom\ 99.7\%\ C.I.\ range\ is\ from\ .237\ to\ .254$

Using the set interval data set, we found an average reaction time of .204 seconds and a standard deviation of .069 seconds. With the same sample size of 700, we calculated an error of .00261. Using the same formula and z-scores for confidence intervals gave us the following ranges.

$Set\ Interval\ 95\%\ C.I.\ =\ .204 \pm 1.96(.0694)/.00261$
$Set\ Interval\ 95\%\ C.I.\ range\ is\ from\ .199\ to\ .209$

$Set\ Interval\ 99.7\%\ C.I.\ =\ .204 \pm 2.96(.0694)/.00261$
$Set\ Interval\ 99.7\%\ C.I.\ range\ is\ from\ .196\ to\ .212$

Question #2
Both the pseudo-random and set interval datasets have 700 data points. In a dataset with a 95% confidence interval, it can be expected that 5% of the data points are located outside of the confidence interval range. Similarly, 0.3% of data points would be expected to be located outside of a 99.7% confidence interval range.

With 700 data points in each set, this means that it would be expected for 35 data points to be located outside of a 95% confidence interval range, and for 2.1 to be located outside of a 99.7% confidence interval range. Because we cannot have fractional data points, this means that we round up to the next whole number and can actually expect three points to be outside of this range.

The range that contains P% of data points is defined as $x \pm z(S_X)$where x is average, z is the z-score of the confidence interval, and Sx is standard deviation. Table 1 shows the average, standard deviation and z-scores for the pseudo-random and set interval data.

Table 1: Average, Standard Deviation, and Z-Scores for Pseudo-Random and Set Interval

	Average (s)	Standard Deviation (s)	95% C.I. z-score	97.7% C.I. z-score
Pseudo-Random	.245	.0753	1.96	2.96
Set Interval	.204	.0694	1.96	2.96

$Pseudorandom\ 95\%\ C.I.\ =\ .245 \pm 1.96(.0753)$
$Pseudorandom\ 95\%\ C.I.\ range\ is\ from\ .098\ to\ .393$

$Pseudorandom\ 99.7\%\ C.I. = .245 \pm 2.96(.0753)$
$Pseudorandom\ 99.7\%\ C.I.\ range\ is\ from\ .022\ to\ .468$

$Set\ Interval\ 95\%\ C.I. = .204 \pm 1.96(.0694)$
$Set\ Interval\ 95\%\ C.I.\ range\ is\ from\ .068\ to\ .340$

$Set\ Interval\ 99.7\%\ C.I. = .204 \pm 2.96(.0694)$
$Set\ Interval\ 99.7\%\ C.I.\ range\ is\ from\ .000\ to\ .409$
From these confidence interval ranges and the given datasets, we can find exactly how many points lie outside of the given ranges. This data is shown in Table 2.

Table 2: Values Outside of the Confidence Intervals

	95% C.I. Range (s)	99.7% C.I Range (s)	Number of Values outside 95% C.I. range	Number of Values outside 99.7% C.I. range
Pseudo-random	.098 to .393	.022 to .468	23	7
Set interval	.068 to .340	.000 to .409	34	8

Question #3
We first separated the data by dominant vs. non-dominant hand. Then we used the =AVERAGE function to calculate the average reaction time for the pseudo-random dominant hand, pseudo-random non-dominant hand, fixed dominant hand, and the fixed non-dominant hand. Next we used =STDEV to find the standard deviation of those same categories. Table 3 shows this data.

Table 3: Averages and Standard Deviations for Dominant vs Non-Dominant

	Pseudo-Random Average (s)	Pseudo-Random Standard Deviation (s)	Fixed Average (s)	Fixed Standard Deviation (s)
Dominant	0.242	0.994	0.202	0.203
Non-Dominant	0.396	0.394	0.206	0.202

We then made a 95% confidence interval of the mean. In our data, there are 35 dominant/non-dominant who all did 20 trials. This gives us sample sizes of 349 and 350 respectively.

Dominant Pseudo-Random
$95\%\ C.I. = .242 \pm 1.96(.994/sqrt(349))$
$95\%\ C.I.\ is\ 0.242 \pm 0.104$

$95\%\ C.I.\ range\ is\ from\ .138\ to\ .346$

Dominant Fixed

$95\%\ C.I.\ =\ .202 \pm 1.96(.203/sqrt(350))$

$95\%\ C.I.\ is\ 0.202 \pm\ 0.0213$

$95\%\ C.I.\ range\ is\ from\ .181\ to\ .223$

Non-Dominant Pseudo-Random

$95\%\ C.I.\ =\ .396 \pm 1.96(.394/sqrt(349))$

$95\%\ C.I.\ is\ 0.396 \pm 0.0413$

$95\%\ C.I.\ range\ is\ from\ .355\ to\ .437$

Non-Dominant Fixed

$95\%\ C.I.\ =\ .206 \pm 1.96(.202/sqrt(350))$

$95\%\ C.I.\ is\ 0.206 \pm 0.0212$

$95\%\ C.I.\ range\ is\ from\ .185\ to\ .227$

The confidence intervals for the dominant pseudo-random do not overlap with the non-dominant pseudo-random, but the intervals between dominant fixed and non-dominant fixed do overlap with each other. This suggests that, under fixed conditions, there is no significant difference in response time between dominant and non-dominant clicks. In addition, under pseudo-random conditions, there was a significant difference between dominant and non-dominant clicks. The lower bound of the non-dominant pseudo-random interval is greater than the lower bound of the dominant pseudo-random interval. This difference demonstrates a faster response time in the dominant hand compared to the non-dominant hand under pseudo random conditions.

Question #4

We first separated the data by gender. Then we used the =AVERAGE function to calculate the average reaction time for pseudo-random female, fixed female, pseudo-random male, and fixed male individually. Next we used =STDEV to find the standard deviation of those same categories. Table 4 shows this data.

Table 4: Averages and Standard Deviations for Female vs Male

	Pseudo-Random Average (s)	Pseudo-Random Standard Deviation (s)	Fixed Average (s)	Fixed Standard Deviation (s)
Female	0.255	0.0773	0.217	0.0671
Male	0.235	0.0719	0.191	0.0693

We then made a 95% confidence interval of the mean. In our data, there are 18 females and 17 males who all did 20 trials. This gives us sample sizes of 360 and 340 respectively.

Female Pseudo-Random

$95\%\ C.I.\ = .255 \pm 1.96(.0773/sqrt(360))$
$95\%\ C.I.\ is\ 0.255 \pm 0.00799$
$95\%\ C.I.\ range\ is\ from\ .247\ to\ .263$

Female Fixed
$95\%\ C.I.\ = .217 \pm 1.96(.0671/sqrt(360))$
$95\%\ C.I.\ is\ 0.217 \pm 0.00693$
$95\%\ C.I.\ range\ is\ from\ .210\ to\ .224$

Male Pseudo-Random
$95\%\ C.I.\ = .235 \pm 1.96(.0719/sqrt(340))$
$95\%\ C.I.\ is\ 0.235 \pm 0.00764$
$95\%\ C.I.\ range\ is\ from\ .227\ to\ .243$

Male Fixed
$95\%\ C.I.\ = .191 \pm 1.96(.0693/sqrt(340))$
$95\%\ C.I.\ is\ 0.191 \pm 0.00737$
$95\%\ C.I.\ range\ is\ from\ .183\ to\ .198$

The confidence intervals for the pseudo-random and fixed reaction time average do not overlap when comparing one gender to the other. The lower bounds of the both female confidence intervals are greater than the upper bound of the male confidence intervals. This shows that the difference in average reaction time between gender is significant.

Question #5
We first separated the data by students who game vs. students who don't game. Then we used the =AVERAGE function to calculate the average reaction time for pseudo-random gamers, pseudo-random non-gamers, fixed gamers, and fixed non-gamers. Next we used =STDEV to find the standard deviation of those same categories. Table 5 shows this data.

Table 5: Averages and Standard Deviations for Gamers vs Non-Gamers

	Pseudo-Random Average (s)	Pseudo-Random Standard Deviation (s)	Fixed Average (s)	Fixed Standard Deviation (s)
Gamers	0.228	0.0760	0.177	0.177
Non-Gamers	0.255	0.255	0.218	0.218

We then made a 95% confidence interval of the mean. In our data, there are 12 gamers and 23 non-gamers who all did 20 trials. This gives us sample sizes of 240 and 459 respectively.

Gamers Pseudo-Random
$95\%\ C.I.\ = .228 \pm 1.96(.0760/sqrt(240))$

$95\%\ C.I.\ is\ \ 0.228 \pm 0.00962$
$95\%\ C.I.\ range\ is\ from\ .218\ to\ .238$

Gamers Fixed
$95\%\ C.I.\ \ = \ .177 \pm 1.96(.177/sqrt(240))$
$95\%\ C.I.\ is\ \ 0.177 \pm 0.0224$
$95\%\ C.I.\ range\ is\ from\ .155\ to\ .199$

Non-Gamers Pseudo-Random
$95\%\ C.I.\ \ = \ .255 \pm 1.96(.255/sqrt(459))$
$95\%\ C.I.\ is\ \ 0.255 \pm 0.0233$
$95\%\ C.I.\ range\ is\ from\ .232\ to\ .278$

Non-Gamers Fixed
$95\%\ C.I.\ \ = \ .218 \pm 1.96(.218/sqrt(459))$
$95\%\ C.I.\ is\ \ 0.218 \pm 0.0199$
$95\%\ C.I.\ range\ is\ from\ .198\ to\ .238$

The confidence intervals have a slight overlap when comparing gamers to non-gamers. The gamers pseudo-random confidence interval is 0.218 to 0.238 seconds while the confidence interval for non-gamers pseudo-random is 0.232 to 0.278 seconds. There is a 0.06 second overlap between the two intervals. Similarly, there is a 0.001 second overlap when looking at the confidence intervals for the fixed reaction times. This shows that there is a difference in reaction time between gamers and non-gamers, but the difference is not significant.

Adaptation Data

Question #6

The purpose of the adaptation trial was to show people can adapt to a consistent time interval and have faster reaction time as the experiment goes on. Calculating an overall average and standard deviation would hide any changes in reaction time that may have occurred.

Question #7

In order to look for any adaptation in the fixed interval reaction time data, we calculated a 95% confidence interval for each event. One event in this case is the first button press for each individual. The second button press is the second event, and so on. We used the same steps as above to find the average and confidence intervals. Example calculations for the first event are shown. Table 6 shows this data.

Table 6: Average and Standard Deviation for Right Hand Fixed Interval Data

	Average (s)	Standard Deviation (s)
Right Hand	0.239	0.0480

Since there are 35 students who recorded data for the lab, our sample size is 35.

Right Hand First Event

$95\%\ C.I.\ =\ .239 \pm 1.96(.0480/sqrt(35))$

$95\%\ C.I.\ is\ 0.239 \pm 0.0159$

$95\%\ C.I.\ range\ is\ from\ .223\ to\ .255$

The confidence intervals for each event can be seen in Figure 1 and Figure 2.

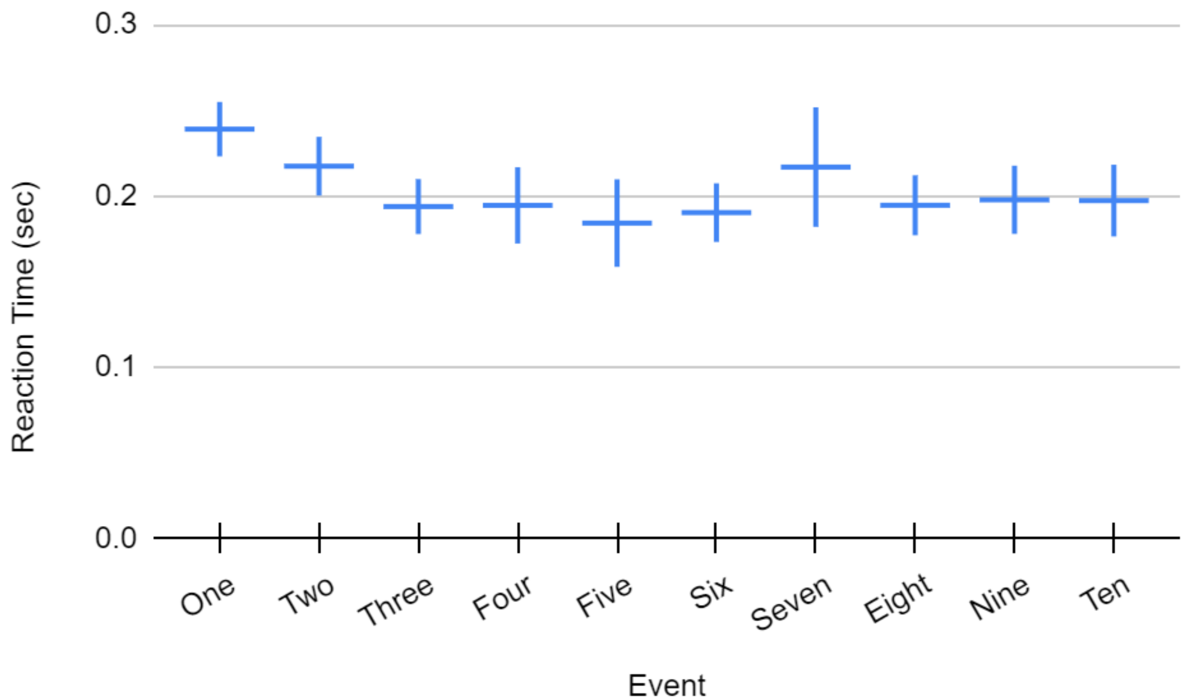

Figure 1. Mean and Standard Deviation of Reaction Time for Right Hand

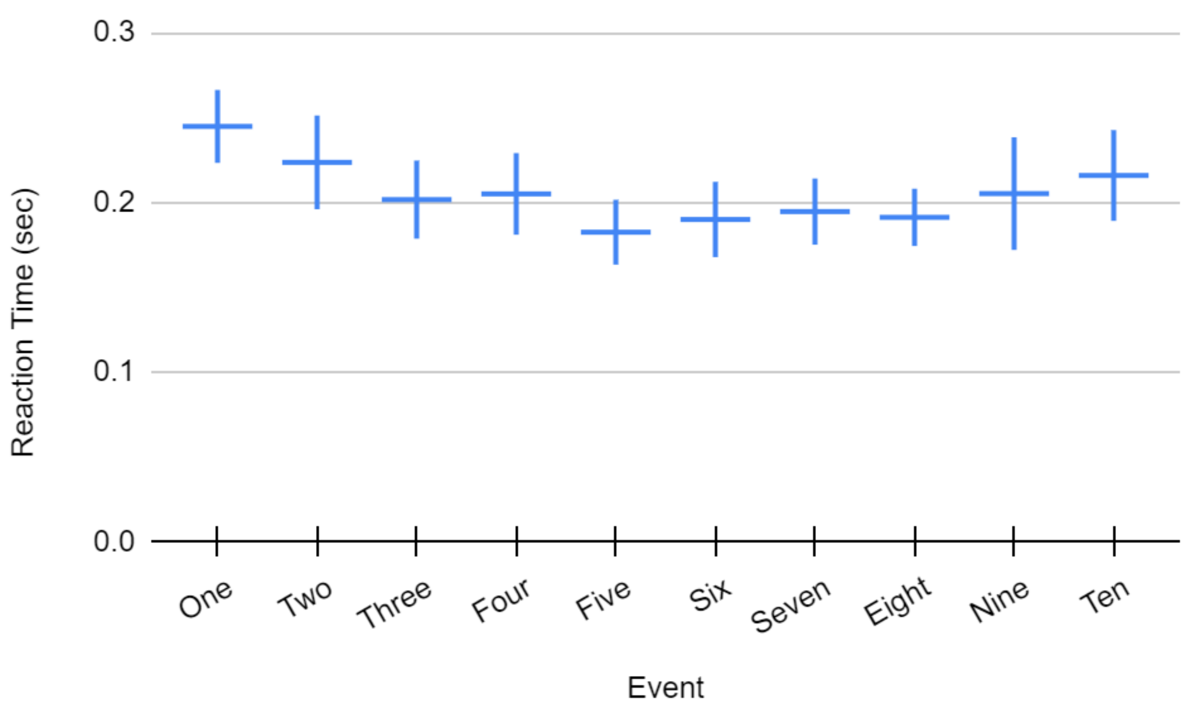

Figure 2. Mean and Standard Deviation of Reaction Time for Left Hand

Looking at the right hand, the 95% confidence interval for the first event is from 0.223 to 0.255 seconds. The last event has a 95% confidence interval of 0.176 to 0.219 seconds. Since the intervals do not overlap, this shows that there is a significant decrease in reaction time for the right hand.

Looking at the left hand, the 95% confidence interval for the first event is from 0.223 to 0.266 seconds. The last event has a 95% confidence interval of 0.189 to 0.243 seconds. This time the intervals do overlap. This shows that there is not a significant decrease in reaction time for the left hand.

In order to look at uncertainty, we first checked if any event has outliers. We did this by calculating a range of $\pm$3 standard deviations around the average. Then we checked if any recorded reaction time for that event is outside the range.

Right Hand First Event

$3\ standard\ deviation\ range\ = .239 \pm 3(.0480)$

$3\ standard\ deviation\ range\ is\ 0.239 \pm 0.144$

$3\ standard\ deviation\ range\ is\ from\ 0.0952\ to\ 0.383$

For this event there were no outliers. When looking at every event, there are no outliers below the minimum value of the range. There are, however, outliers greater than the maximum value in 8 of the events. These could be explained by people either missing the noise or failing to press down the button enough to be registered. An outlier below the minimum range could only be explained by a reaction time that is too fast to be realistically done.

The frequency of reaction times for the first event for the right hand is shown in Figure 3. The distribution appears relatively normal with a slight skew to the right. This can again be explained by the fact that people could either miss the noise or not properly trigger the button. Each event shares this general shape for the distribution of reaction times.

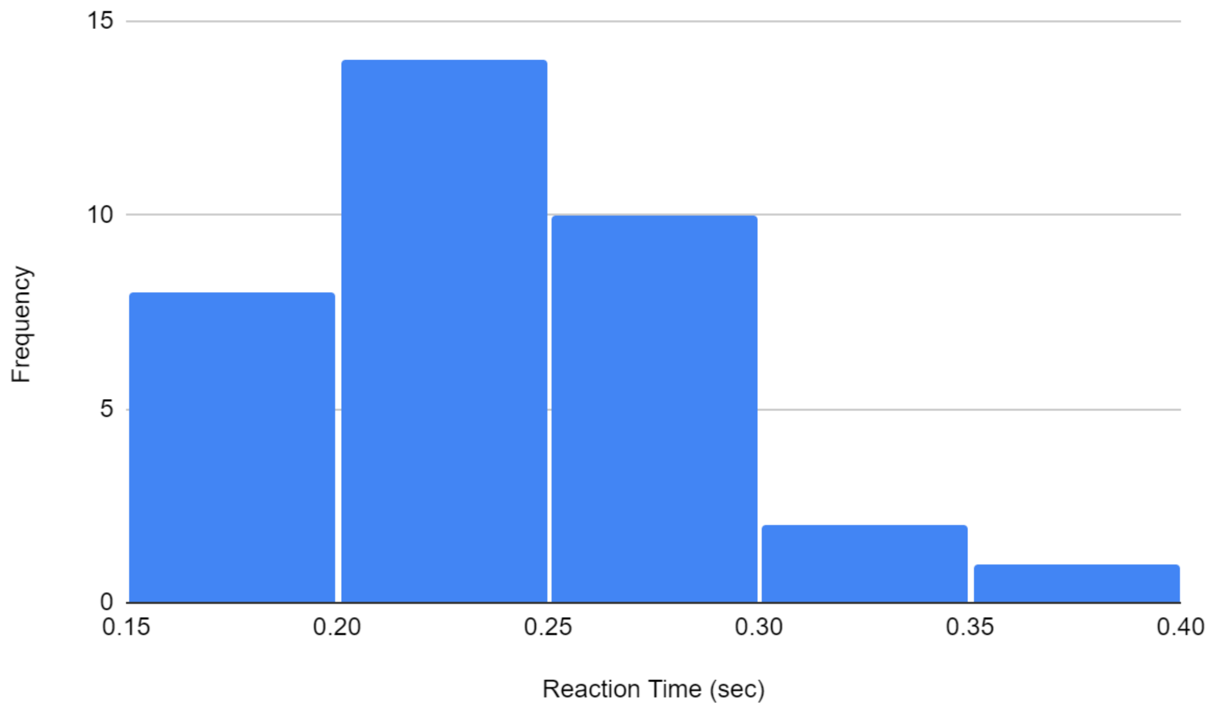

Figure 3. Reaction Time Frequency for Right Hand Event 1

For this experiment, we expect our data to be relatively stable. Most people will have similar reaction times, without too much variability around the average. In addition, each individual should have a similar reaction time for the whole experiment. The experiment did not run long enough to expect any significant change due to exhaustion or other variables. The data we collected matches these expectations.

Since there are few outliers, the data distribution is roughly normal, and there was no unexpected variability, we can be fairly certain about our results and conclusions.

Question #8

Proof of overall adaptation could be shown by blocking the first and second half of a given individual's ten-point test. The difference between the averaged points 1 through 5 and the averaged points 6 through 10 should be a positive number. This number will be called the adaptation delta (Δa). By averaging every individual's Δa, splitting data sets by left or right hand, we can find the average change between the first and second halves of the adaptation set in the overall sample size.

In excel, the first half and second half of each individual's set-interval data set was averaged. The first half of the left and right hand datasets are denoted as L1 and R1, while the second half is denoted as L2 and R2. After finding these values for each individual, the difference between half sets were found by subtracting set 1 from set 2. A negative result denotes improved adaptation from the first half to second half. This value was denoted as δR and δL. Finally, all δR values were averaged together, as were all δL values.

The average adaptation change for the right hand, for Avg. δR, was -0.0077 seconds. The average adaptation change for the right hand, for Avg. δR, was -0.0121 seconds. This shows that the reaction time of the sample set as a whole trended downward between the first and second halves of the ten-point test. This data is shown in Figure 4.

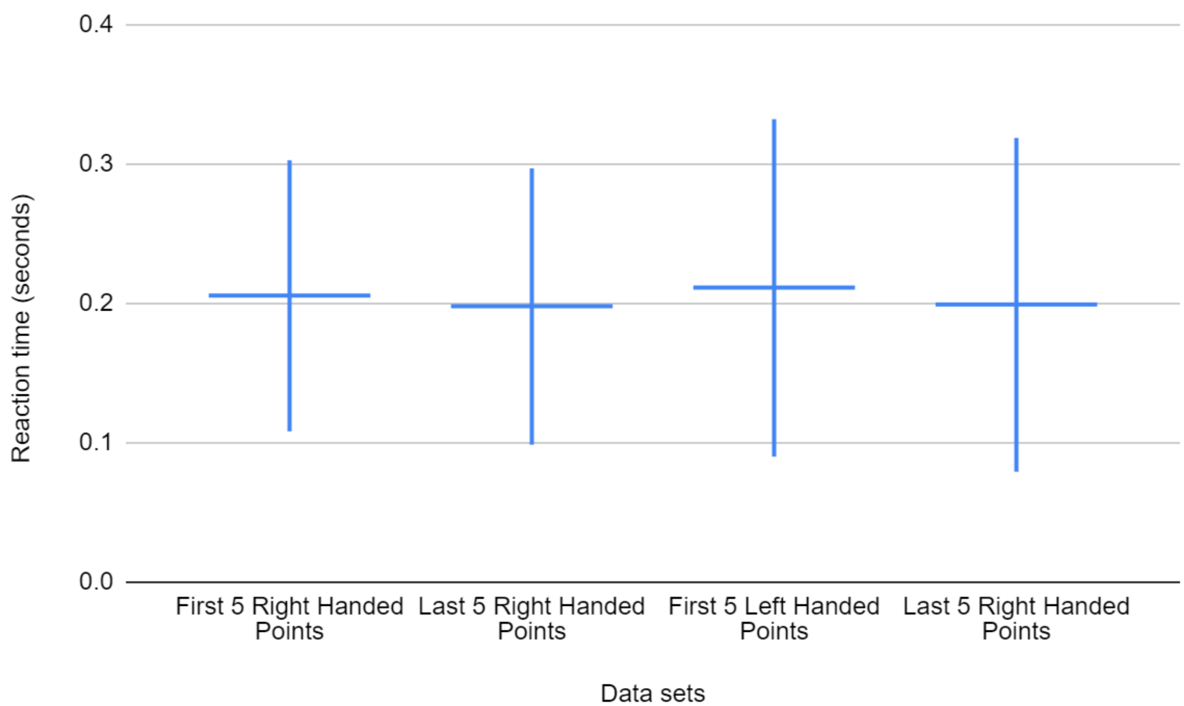

Figure 4. First and Last Five Set-Interval Data Points per Hand - 95% Confidence Interval

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Threshold Data

Question #9

Using the Excel = AVERAGE() function, we found the average threshold voltage to be 1.78mV. We then used = STDEV() to find the standard deviation, which is 1.44. We then made a 95% confidence interval of the mean, meaning our z value is 1.96, and our sample size is 699. The 95% confidence interval range is from 1.67 to 1.89mV. We therefore estimate the true threshold voltage to be between 1.67mV and 1.89mV at a 95% confidence level.

Threshold Data

$95\%\ C.I.\ = 1.78 \pm 1.96(1.44/sqrt(699))$

$95\%\ C.I.\ is\ 1.78 \pm 0.107$

$95\%\ C.I.\ range\ is\ from\ 1.67\ to\ 1.89$

Question #10

In order to estimate the variability in the threshold for an individual click the standard deviation of the data was found using the function = STDEV(), giving the value of 1.44. Using this value, a 95% confidence interval of the mean was determined to be from 1.67 to 1.89, using a z value of 1.96 and a sample size of 699.

To gauge for any outliers the range of three standard deviations from the mean was determined below:

$3\ standard\ deviation\ range\ =\ 1.78\ \pm\ 3(1.44)$

$3\ standard\ deviation\ range\ =\ 1.78\ \pm\ 4.32$

$3\ standard\ deviation\ range\ is\ from\ -2.54\ to\ 6.1$

All of the data points fall within this range, suggesting minimal variability and normal data distribution.

Extra Credit

Question #11

The average of the data was 0.225, which can be seen in the histogram below. Connor had an average of 0.181, Lauren had an average of 0.197, Mathew had an average of 0.185, and Ricky had an average of 0.172, giving the group an average of 0.184. The group average was .186, the standard deviation is 0.0471, z value is 1.96, and the sample size is 200. Our group's confidence interval was .179 to .193, while the class's confidence interval was .221 to .229. Our group's confidence interval was slightly lower than the classes. The confidence intervals for the class data and the group data do not overlap. This suggests that there is a significant difference in response time between the class data and group data clicks. This can be seen in Figure 5.

Class Data

$95\%\ C.I. \ = \ 0.225 \pm 1.96(.0753/sqrt(1398))$

$95\%\ C.I.\ is\ 0.225 \ \pm 0.00395$

$95\%\ C.I.\ range\ is\ from\ .221\ \ to\ .229$

Group Data

$95\%\ C.I. \ = \ .186 \pm 1.96(.0472/sqrt(200))$

$95\%\ C.I.\ is\ .186 \pm 0.00654$

$95\%\ C.I.\ range\ is\ from\ .179\ \ to\ .193$

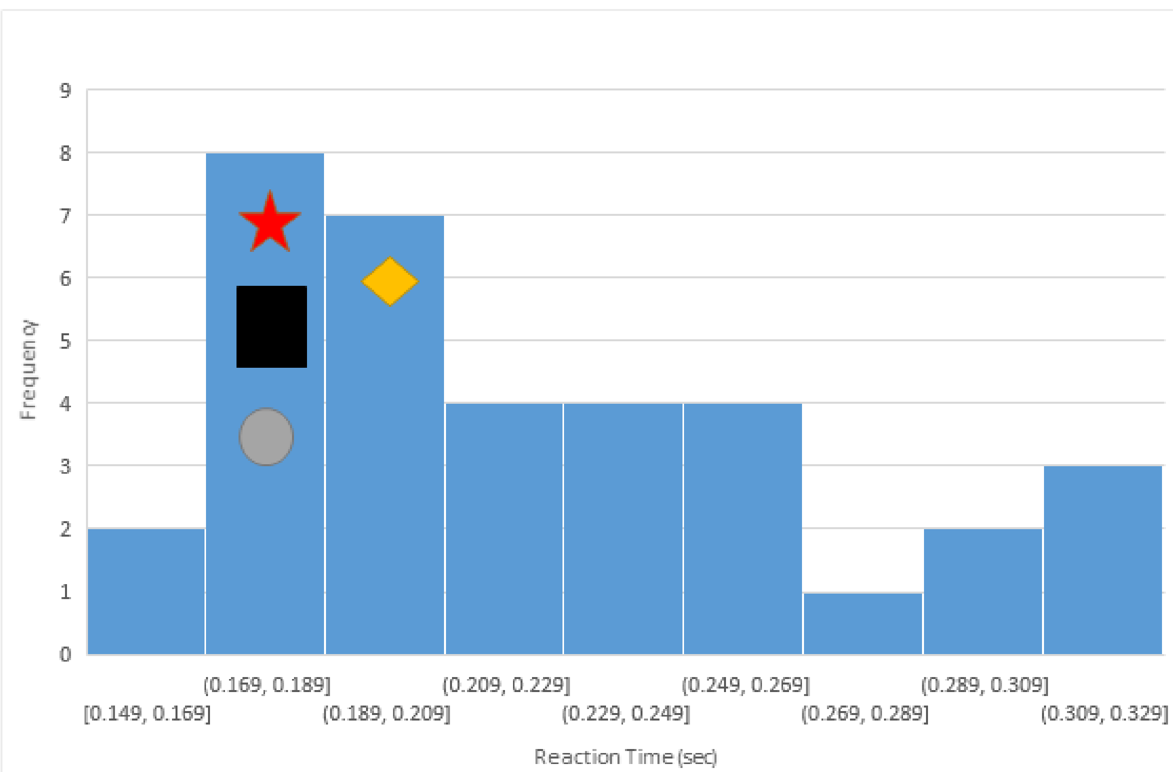

Figure 5. Histogram of Overall Average Reaction Times.
Red Star = Connor, Black Box = Mathew, Grey Circle = Ricky, Yellow Diamond = Lauren