EE145M
Lab2 Reaction Time
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Lab Time: Wednesday 10-1pm
Lab Station: 12
Lab Partner: Bill Hung

Aim
To measure the human response time, and use the Student's t test to determine whether the difference of two means is due to chance.

1. Setup

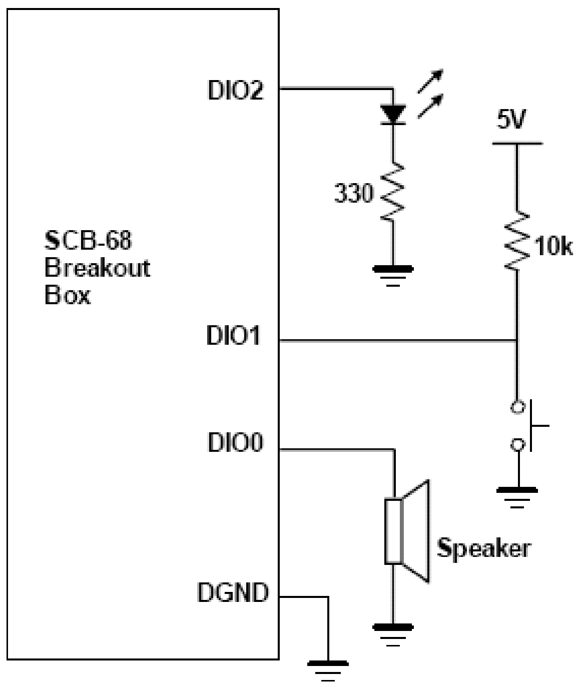


Figure the instruments used to determine response time

The interface between the SCB-68 breakout box and the circuit is shown above. The LED and the speaker act as prompts of the experiment. The switch takes user's response to DIO1. The reaction time will be measured and displayed on the front panel of ResponseTime.vi.

2. Procedure and Data Summary

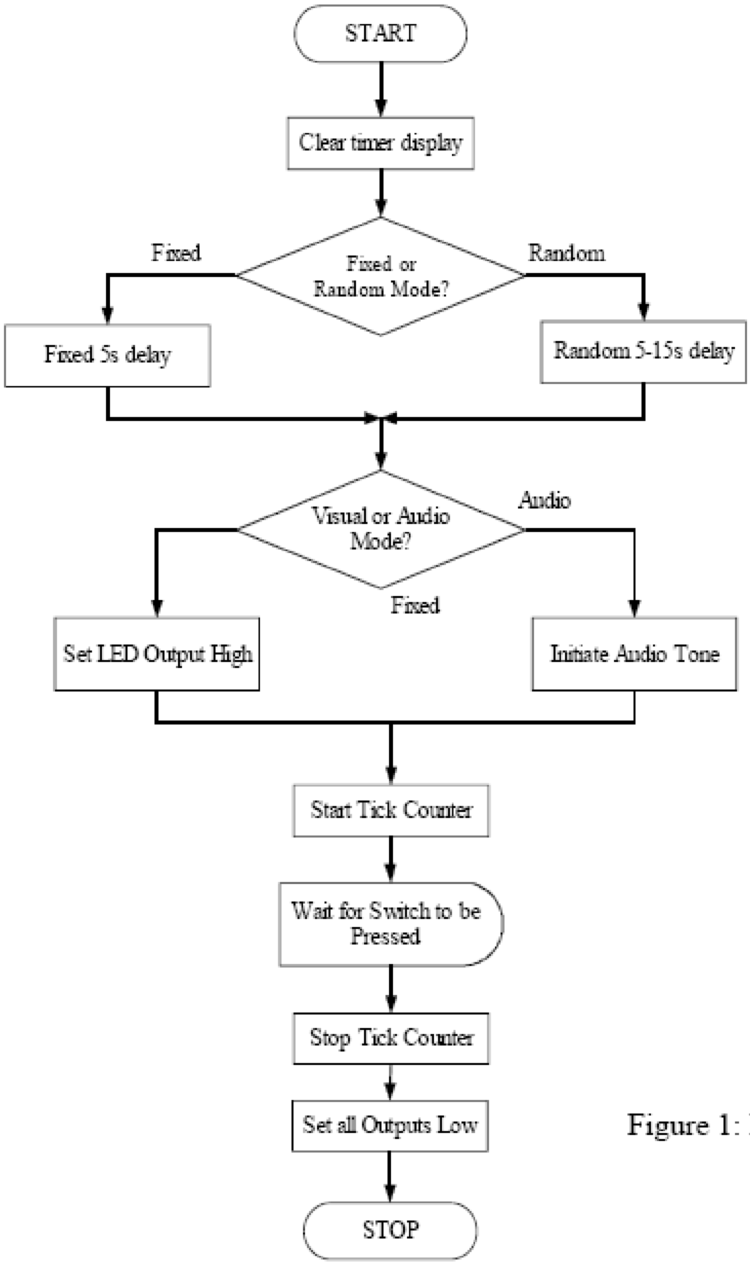


Figure 1: Flow Chart for Lab 2

2.1 Procedure

After setting up the circuit in **Section 1**, it is time to construct the VI. Figure 1 shows the flow chart of the VI in this lab.

Create a Front Panel like Figure 3. We will break the program into four sequential steps, so we need a **flat sequence structure**. In the first panel, we will reset the response time indicator to zero. Then, generate a delay, random or fixed, based on the user's decision, and pass it to the second panel. The second panel simply waits there until the delay is reached. The third panel will start the response timer, and will output either sound or light based on the user's decision. The sound is generated from a square wave; the **Loop Timer** indicates the duration of iteration of the **While Loop**, which also represents the width of the pulse. The **While Loop** is terminated by **Continue if True** because of the pullup resistor; DIO1 is always high unless the switch is pressed. Once the loop is terminated, the speaker will turn off since no more square waves are generated. However, we still need to turn off the LED. This is done in the fourth panel.

2.2 Learning Curve

On the front panel, select Fixed Delay, and Visual Prompt (LED). Each laboratory partner measures a series of 10 response times.

	Bill's response (ms)	Dennis' response (ms)		Bill's response (ms)	Dennis' response (ms)
Pass 1	280	276	Pass 2	184	208
	237	237		252	215
	220	217		209	209
	218	240		141	217
	202	206		209	263
	218	210		182	219
	184	216		178	267
	185	247		201	213
	209	183		191	195
	178	189		100	181

2.3. Response to a visible prompt with fixed delay

After the training provided in the previous section, each laboratory partner measures 10 response times with a fixed delay of 5 seconds.

Bill's response (ms)	Dennis' response (ms)
184	227
190	208
174	193
161	199
112	217
152	209
146	217
178	220
190	176
163	217

2.4. Response to a visible prompt with random delay

On the front panel, select Random Timing. There will be a fixed 5s delay followed by a variable delay between 0 and 10 seconds. Repeat as above to obtain 10 results for each laboratory partner.

Bill's response (ms)	Dennis' response (ms)
207	251
185	288
248	334
246	235
208	282
262	207
240	238
222	239
192	350
220	244

2.5. Response to an audible prompt with random delay

On the front panel, select Random Timing, Audio Prompt. Repeat previous section.

Bill's response (ms)	Dennis' response (ms)
144	240
193	206
214	231
171	182
159	213
211	199
196	220
191	211
218	193
190	201

2.6. Minimum response time

Determine the minimum delay that can be measured using both the visible prompt and the audible prompt.

	Visible Prompt	Audible Prompt
Minimum response time (ms)	0	0

3. Analysis

Standard deviation:

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}.$$

Standard error of the mean:

$$\sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}}$$

3.1 Average delays and uncertainties

From **2.2 Learning Curve**

	Bill (Pass 1)	(Pass 2)	Dennis (Pass 1)	(Pass 2)
Average delay (ms)	213.1	184.7	222.1	218.7
Standard deviation (ms)	30.09411	41.03128887	28.20737	26.94871673
Standard error of the mean (ms)	9.516594	12.97523282	8.919953	8.521932488

From **2.3 Response to a visible prompt with fixed delay**

	Bill	Dennis
Average delay (ms)	165	208.3
Standard deviation (ms)	24.08319	15.19539
Standard error of the mean (ms)	7.615773	4.805206

From **2.4 Response to a visible prompt with random delay**

	Bill	Dennis
Average delay (ms)	223	266.8
Standard deviation (ms)	25.51688	46.04056
Standard error of the mean (ms)	8.069146	14.5593

From **2.5 Response to an audible prompt with random delay**

	Bill	Dennis
Average delay (ms)	188.7	209.6
Standard deviation (ms)	24.19389	17.44961
Standard error of the mean (ms)	7.650781	5.518051

From **2.6 Minimum response time**
Since the result was zero in both cases, doing analysis would not be meaningful.

3.2 Student's t test (visible – fixed versus random)
Comparing the reaction time for a visible prompt between fixed and random delays

	Bill
d(ms) = difference of the 2 averages	-58
sigma_d(ms) = (sum of the squared standard error of the mean)^0.5	11.09554
t = d / sigma_d	-5.22732

The number of degrees of freedom: 10 + 10 – 2 = 18
According to Table 5.2, we find that $P(>|t|) \sim 0.00004$, which means that t values outside the range from -1.65 to 1.65 occur 0.004% of time. Therefore, the null hypothesis is extremely unlikely and we may reject the possibility that the difference in the means occurred by chance.

3.3 Student's t test (random – visible versus audible)
Comparing the reaction time for a random delay between visible and audible prompts

	Bill
d(ms) = difference of the 2 averages	34.3
sigma_d(ms) = (sum of the squared standard error of the mean)^0.5	11.11960231
t = d / sigma_d	3.084642691

The number of degrees of freedom: 10 + 10 – 2 = 18
According to Table 5.2, we find that $P(>|t|) \sim 0.005$, which means that t values outside the range from -0.98 to 0.98 occur 0.5% of time. Therefore, the null hypothesis is extremely unlikely and we may reject the possibility that the difference in the means occurred by chance.

3.4 Student's t test (different laboratory partners)
Comparing the reaction time for the difference between laboratory partners in section 2.5

	Bill and Dennis
d(ms) = difference of the 2 averages	-20.9
sigma_d(ms) = (sum of the squared standard error of the mean)^0.5	9.433098
t = d / sigma_d	-2.2156

The number of degrees of freedom: 10 + 10 – 2 = 18
According to Table 5.2, we find that $P(>|t|) \sim 0.4$, which means that t values outside the range from -0.70 to 0.70 occur 40% of time. Therefore, we cannot rule out the null hypothesis and must accept the possibility that the difference in the means occurred by chance.

4. Discussion
4.1 *Discuss the subject's perceptions and any improvement in reaction time during the learning process for a fixed delay (procedure sections 2 and 3).*
According to Analysis 3.1, one can see that the subject's perception has improved because the subject is more familiar with the experiment. During **2.2 Learing curve** section, both Bill and Dennis have better average delay time in Pass 2; however, since both of them just started to learn

the task, the standard deviation and the standard error of the mean were very large. As Bill and Dennis practiced more and more, their results are more accurate. During **2.3 Response to a visible prompt with fixed delay** section, both of them have smaller average response time, smaller standard deviation and standard error of the mean. This means that both of them are used to the task, so that they have relative consistent results.

4.2 *Discuss the difference in the reaction times of the two laboratory partners. Using your Student's t analysis, was one individual significantly faster?*
According to the Student's t test in Analysis 3.4, there is no significantly difference between two laboratory partners. It is possible that the two partners are well trained after so many experiments. However, after a closer look at the data in Analysis 3.1, both Bill and Dennis have quite large standard deviation, which means the measurements have poor accuracy so that successive measurements doesn't yield relatively consistence. Therefore, in order to see the differences, we need to have more accurate measurements and more samples are needed.

4.3 *Discuss the subject's perceptions in reacting to a random delay (procedure section 4) compared with a fixed delay (procedure section 3). Using your Student's t analysis, was one reaction time significantly faster?*
According to Analysis 3.2, one can see that Bill's perception is different in the two experiments (fixed versus random visible prompt). Because with a fixed delay, Bill was able to anticipate the prompt using a "mental clock", so the response time was faster. On the other hand, with a random delay, Bill didn't know when LED would turn on. In addition, from Student's t test analysis, the difference was not due to chance; the difference came from running experiment with two different conditions: random versus fixed delay.

4.4 *Discuss the subject's perceptions in reacting to an audible prompt (procedure section 5) compared with a visible prompt (procedure section 4). Using your Student's t analysis, was one reaction time significantly faster?*
According to Analysis 3.2, one can see that Bill's perception is different in the two experiments (random visible versus audible). Visible perception and audible perception are different, so there is a difference in Bill's reaction time. In addition, Student's t test conveyed that the difference was not due to chance; the difference came from running experiment with two different conditions: visible versus audible prompt.

4.5 *Discuss how the ability of an experiment to determine whether a measurable quantity is actually different under two different experimental conditions is determined by the design of the experiment. Consider the accuracy of each measurement, the number of observations, control over confusing variables, using subjects as their own controls, etc.*
In order to determine whether a measurable quantity is actually different under two different experimental conditions, we need to have a good control of the variables, and make sure they are only one variable is changing as we change the experimental condition. In addition, it is always a good idea to collect more data than we need, so that we are able to see the difference. Besides, we need to have some rules so that different subjects can obtain accurate results.

5. Questions

5.1 *Briefly explain how the while loop in the 3rd pane of the block diagram produces an audible tone. What is the frequency of the tone? And what would the ramifications be if you simply tried to change the frequency without redesigning the block diagram?*

The frequency of the tone is 1/(2*loop time) = 1/(2*1ms) = 500 Hz. It is not easy to change the frequency without redesign the block diagram. The loop timer in the third panel serves 2 purposes. It is used to specify the duration of iteration, 1 millisecond in our case. We took the advantage of it. We simply connect the number of iterations terminal of the while loop to the timer, a numeric indicator. In other words, the number of iterations is the reaction time in millisecond. Therefore, if we simply change the duration of iteration, the frequency of the tone will change, but the loop no longer gets increment every millisecond, so it cannot be used to output response time anymore.

5.2*Suppose that you are convinced that a measured quantity really depends on some experimental variable, but after doing a preliminary experiment, you find that the Student's t value is too low to prove your case. What could you do to pursue the issue further?*

I will check the standard deviation and the standard error of the means. If they are small, we can take more measurements. However, if the standard deviation and the standard error of the means are large, it means measurements taken with each experimental variable are not accurate enough. We need to improve the accuracy, and then collect more data.

As the number of measurements increases, and if t increases, we can rule out the null hypothesis. However, if t decreases, we can not rule out the null hypothesis. It is possible that the difference between the means is due to chance. It is also possible that the experimental variables are related somehow, so that the results are almost indistinguishable. For example, if the experimenters are race car drivers, and they are well trained and have enough rest, the response times might be very close.

5.3*What minimum intervals did you get in Part 6 of the lab? Would you expect the same results if a PC based acquisition system was used (such as the MIO-16E, or the old DT3010 board? Explain.*

The minimum interval is 0s. The FPGA board has a fixed sample rate, so that the result is predictable and consistent. One the other hand, the MIO-16E board is a Data Acquisition (DAQ) board, without any built-in timing device. The computer is responsible for the timing control. Even though it can operate faster than human reaction time, it still has problem; the timing might not be accurate since hardware or software applications can interrupt timing.

6. Program and laboratory data sheets

6.1 Include printouts of your VI front panel and block diagram.

Figure 3: The Front Panel of ResponseTime.vi

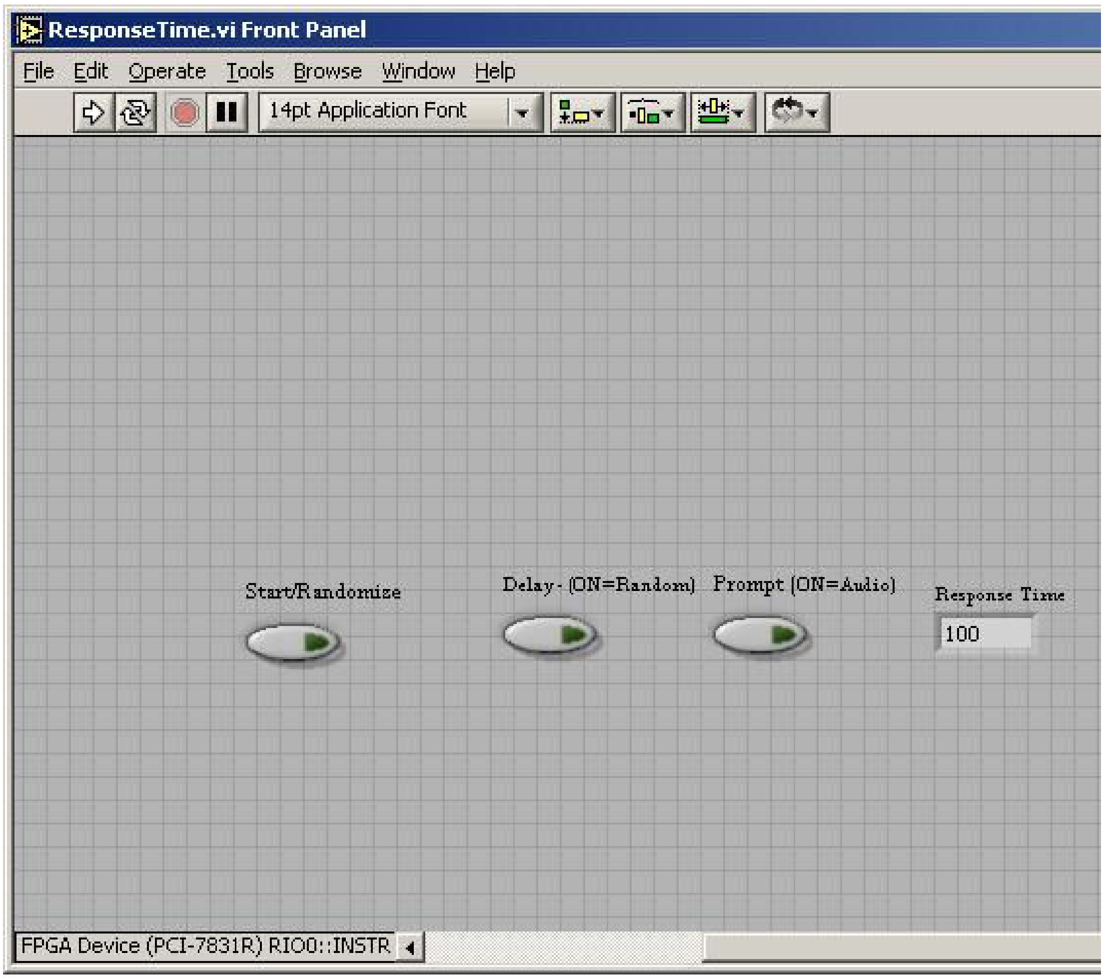
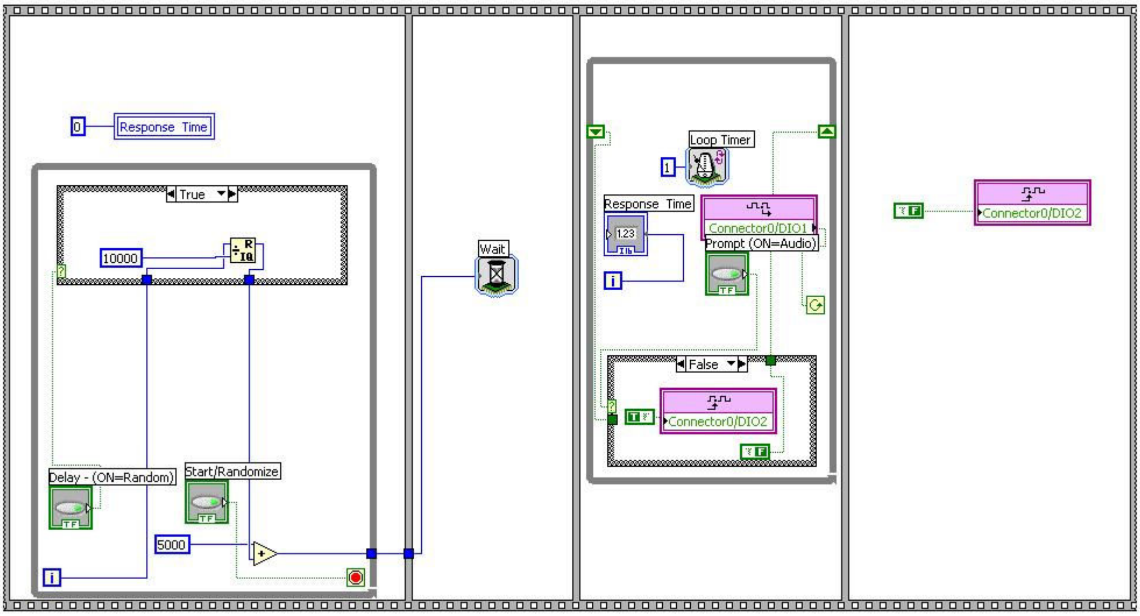


Figure: The Block Diagram of ResponseTime.vi



6.2 Include handwritten or typed up data sheets which should consist of the measurements you recorded manually, and any notes not already discussed in the lab.

Lateness	
Setup	
Procedure and Data Summary	
Analysis	
Discussion	
Questions	
Clarity	
Total grade	