Lesson 11
Reaction Time I
I. INTRODUCTION

The beginning of a race is a classic example of a stimulus-response situation, where people hear a stimulus (the starter’s pistol) and react to it in some way (response). There are two key factors in stimulus-response: reaction time and learning.

- **Reaction time** is the delay between when the stimulus is presented and when you do something about it.
- **Learning** is the acquisition of knowledge or skills due to experience and/or instruction.

The delay between hearing the signal and responding is due to the time for the afferent signal to reach the brain and for the brain to send an efferent signal to the muscles. With learning, the time for the various steps in the process can be shortened. Reaction time varies from person to person and from situation to situation, and most people have delayed reaction times late at night and early in the morning.

As people learn what to expect, reaction time typically decreases. Imagine a young man entering a track event for the first time. When the pistol goes off, he might not know what to do, but after everyone around him started running he would get the idea and start running as well. In the next race, you would expect him to start at about the same (although not exact) time as everyone else, assuming some learning took place in the meantime. With practice, and more importantly, learning, his reaction times could be cut from a few seconds to fractions of a second.

Some years ago, a world-class runner was repeatedly accused by his competitors of “jumping the gun” in races. He could only respond to these accusations by saying that he felt he had done nothing wrong. When footage of his races was reviewed, it became clear that he was in fact leaving the starting blocks before his competitors. As the evidence against him mounted, he underwent physiological testing which measured how long it took him to respond to external events or stimuli. It was revealed that his responses were some five to ten percent faster than those of an average runner, and this slight advantage enabled him to react faster once he heard the starter’s pistol.

This lesson shows how easily and rapidly people learn, as demonstrated by their ability to anticipate when to press a button. The lesson uses a relatively simple variation of stimuli (pseudo-random vs. fixed interval) to determine what results in the shortest reaction times.

- In the case of pseudo-random presentation, it takes longer for reaction times to decrease and the decrease is less than as occurs with fixed-interval presentation.
- When fixed-interval trials are repeatedly performed, average reaction time typically decreases each time new data is recorded, up to a point. Eventually, the minimal reaction time required to process information is reached and reaction time becomes constant.

Usually, longer reaction times are a sign that people are paying less attention to the stimuli and/or are processing information. That is, if it took you more time to respond to clicks while also reading a book than when you were also watching TV, then you could infer that you were probably paying more attention to the book than to TV since your brain took longer to respond. Deriving these types of measures from simple reaction time tests allows researchers a glimpse into the cognitive and neurological functioning of people as they perform tasks.
This lesson takes a relatively simple look at reaction time and how changing one small aspect of a procedure can result in differences in reaction times. You will probably notice a difference in average reaction times between the pseudo-random and fixed interval presentation trials, and this difference will most likely favor the segments with fixed-interval presentation of stimuli. Part of this difference is probably due to the random vs. non-random presentation of the stimuli. However, you might have also noticed that reaction time decreased from pseudo-random presentation to fixed-interval presentation, suggesting that maybe you just got better with practice.

In more complex investigations, people might be placed in two different conditions (e.g., happy vs. sad, watching TV vs. reading a book) and their reaction time for each condition would be measured. Variations on this theme present people with hundreds of stimuli, often in the form of words or pictures.

Although not covered here, such investigations might measure the alpha-band EEG in addition to response time as another indicator of attention, and review the connection between reaction times and alpha-band EEG activity when people are paying attention to a TV program versus when they are relatively relaxed.

The process of changing the order of presentation for different groups of people is known as counterbalancing and is commonly performed in psychological, medical and other types of research investigations that use experimental procedures. By comparing the reaction time difference between trials with differing order of presentation, you can see how learning contributes to reaction times.

In order to compare the reaction times from the two types of presentation schedules, you can summarize the results as statistics or measures of a population. There are certain statistics that are usually reported for the results of a study: mean, range, variance, and standard deviation. Mean is a measure of central tendency. Range, variance and standard deviation are measures of distribution or the “spread” of data.

- The mean is the average or the sum of the reaction times divided by the number of subjects (n).
- The range of scores is the highest score minus the lowest score. The range is affected by extremely high and low reaction times, so investigators also describe the “spread” or distribution of times with two related statistics: variance and standard deviation.
- Variance is determined by calculating the average squared deviation of each number from its mean.
- Standard deviation is the square root of the deviance.

Using the statistics of mean and distribution, investigators can compare the performance of groups. In this lesson, you will calculate your group statistics but you will not do any formal comparisons between groups.

II. EXPERIMENTAL OBJECTIVES

1) Observe the effects of learning and physiological processes on reaction times.
2) Compare reaction times with two presentation schedules: fixed intervals and pseudo-random intervals.
3) Calculate statistics of group mean, variance, and standard deviation.
III. MATERIALS

- BIOPAC SS10L Hand switch
- BIOPAC OUT1 Headphones
- Computer system:
  - Macintosh® - minimum 68020
  
  or
  
  PC running Windows® 95/98/NT 4.0/2000
- Memory requirements:
  The Biopac Student Lab application needs to have at least 4MB of RAM available for its needs. This is 4MB above and beyond the operating system needs and any other programs that are running.
- BIOPAC Student Lab software v3.0.7 or greater
- BIOPAC acquisition unit (MP30)
- BIOPAC wall transformer (AC100A)
- BIOPAC serial cable (CBLSEREA)
IV. EXPERIMENTAL METHODS

Overview

➢ As you complete the Experimental Methods (Set Up, Calibration, and Recording) and the Analysis, you may need to use the following tools and display options. The window display shown below is only a reference sample — it does not represent any lesson specific data. The sample screen shows 3 channels of data and four channel measurement boxes, but your screen display may vary between lessons and at different points within the same lesson.

The symbols explained below are used throughout Experimental Methods and Analysis.

Key to Symbols

➢ The data collected in the step needs to be recorded in the Data Report (in the section indicated by the alpha character). You can record the data individually by hand or choose **Edit > Journal > Paste measurements** to paste the data to your journal for future reference.

➢ Most markers and labels are automatic. Markers appear at the top of the window as inverted triangles. This symbol is used to indicate that you need to insert a marker and key in a marker label similar to the text in quotes. You can insert and label the marker during or after acquisition. On a Mac, press “ESC” and on a PC, press “F9.”

➢ Each section is presented in a two-column format, as described below.
A. SET UP

<table>
<thead>
<tr>
<th>FAST TRACK Set Up</th>
<th>Detailed Explanation of Set Up Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Turn your computer ON.</td>
<td>The desktop should appear on the monitor. If it does not appear, ask the laboratory instructor for assistance.</td>
</tr>
<tr>
<td>2. Make sure the BIOPAC MP30 unit is OFF.</td>
<td></td>
</tr>
</tbody>
</table>
| 3. **Plug the equipment in** as follows:  
  Hand switch (SS10L) — CH 1  
  Headphone (OUT1) — back of unit | **Hand switch (BIOPAC SS10L)**  
  Plugs into CHannel 1 |
| 4. Turn **ON** the BIOPAC MP30 unit. | **Headphones (BIOPAC OUT1)**  
  Plugs into back of MP30 unit |
| 5. **Start** the BIOPAC Student Lab Program. | |
| 6. Choose lesson **“L11-React-1”** and click **OK**. | |
| 7. Type in a unique **filename**. | No two people can have the same filename, so use a unique identifier, such as the subject’s nickname or student ID#. |
| 8. Click **OK**. | This ends the Set Up procedure. |

**END OF SET UP**
B. CALIBRATION

This calibration procedure will check that the headphones and SS10L are properly connected. Otherwise, there are no settings to adjust or change.

**FAST TRACK Calibration**

1. Prepare the **Subject** for the calibration recording.

2. Click on **Calibrate** then click **OK**.

3. **Press the SS10L hand switch when you hear a click.**

4. **Wait** for the calibration to end.

**Detailed Explanation of Calibration Steps**

Subject should be seated in a relaxed state, with headphones on, eyes closed. The **Subject** should hold the hand switch with his/her dominant hand, such that the thumb is ready to press the button.

**Note:** When the Calibrate button is hit in the next step, it’s possible that the volume through the headphones may be very loud due to system feedback. The volume cannot be adjusted, so you may have to position the headphones slightly off the ear to reduce the sound.

Before the calibration begins, a pop-up window will appear reminding you to press the button when you hear a click. Click **OK** to begin the calibration recording.

When pressing the hand switch, **Subject** should briefly depress the button, then release; **Subject** should not hold the button down or press it more than once.

You should hear the click approximately four seconds into the recording.

The calibration will run for 8 seconds and will automatically stop, so let it run its course.
5. **Review** the data on the screen.
   - If correct, proceed to the Data Recording Section.
   - If **Calibrate** button reappears in the window, check connections and repeat the calibration procedure, making sure to press button firmly.
   - If incorrect, **Redo**.

Your screen should be similar to Fig. 11.3.

![Fig. 11.3 Sample calibration data](image)

If there was no signal detected from the hand switch (flat line at 0 millivolts), the program will automatically return you to the beginning of the calibration procedure.

*If this happens:* Check the connections to the hand switch, make sure you’re pressing the button firmly, and redo the calibration procedure.

If your calibration screen does not resemble Fig. 11.3, you need to repeat calibration to obtain a similar screen.

Data would be incorrect if:

a) The baseline is not 0 millivolts

b) The data is excessively noisy, meaning more than approximately 1mV peak-to-peak.

   Note: Your data may be a little more or less noisy than the example above.

Click **Redo calibration** and repeat the procedure.
C. RECORDING LESSON DATA

<table>
<thead>
<tr>
<th>FAST TRACK Recording</th>
<th>Detailed Explanation of Recording Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prepare for the recording.</td>
<td></td>
</tr>
<tr>
<td><strong>IMPORTANT</strong> Never manually insert a marker in any recording segment of this lesson.</td>
<td></td>
</tr>
<tr>
<td>2. Prepare the <strong>Subject</strong> and <strong>Director</strong> for the recording.</td>
<td></td>
</tr>
</tbody>
</table>

**Segment 1: Pseudo-random Trial 1**

3. Click on **Record**.

4. **Subject** should **press and release** the push-button switch on the SS10L at the sound of each click.

When you click on **Record**, a pseudo-random presentation trial will begin.

*Pseudo-random presentation*: The clicks will come at pseudo-random intervals, in this case at least one second apart but no more than ten seconds apart.

As soon as you hear each click through the headphone, press and release the push-button switch on the SS10L.
5. **Review** the data on the screen.
   - If **correct**, go to **Step 6**.
   - If **incorrect**, click **Redo**.

   A **marker** will automatically be inserted each time a click is output.
   Also, each time you press the push-button on the SS10L, an upward pointing “pulse” will be displayed on the screen.

   The recording will suspend automatically after ten clicks.

   After ten 10 clicks, the resulting graph should resemble Fig. 11.4. There should be a pulse displayed after each marker if the button was pressed correctly.

   ![Fig. 11.4 Clicks indicated by pulse and marker](image)

   **Segment 2: Pseudo-random Trial 2**

   6. Click on **Resume**.

   The recording will continue from the point it last stopped, and a marker labeled “repeat pseudo-random” will automatically be inserted when **Resume** is pressed.

   You will record a second pseudo-random presentation trial.

   As soon as you hear each click through the headphone, press and release the push-button switch on the SS10L.

   The recording will suspend automatically after ten clicks.

   After ten 10 clicks, the resulting graph should resemble Fig. 11.4 above.

   Data would be incorrect for the same reasons as in Step 5.

   To redo, click **Redo** and repeat Steps 6-8.

   - **If correct**, go to **Step 9**.
   - **If incorrect**, click **Redo**.

   **Recording continues…**
### Segment 3: Fixed Interval Trial 1

9. Click on Resume.  

The recording will continue from the point it last stopped, and a marker labeled “fixed-interval” will automatically be inserted when Resume is pressed.

You will record a fixed-interval presentation trial.

*Fixed interval presentation:* The clicks will come at fixed intervals, every four seconds.

As soon as you hear each click through the headphone, press and release the push-button switch on the SS10L.

The recording will suspend automatically after ten clicks.

10. Subject should **press and release** the push-button switch on the SS10L at the sound of each click.

11. **Review** the data on the screen.

   - If correct, go to Step 12.
   - If incorrect, click Redo.

After 10 clicks have been output, the resulting graph should resemble Fig. 11.4 above.

Data would be incorrect for the same reasons as with Fig. 11.4. To redo, click Redo and repeat Steps 9-11.

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### Segment 4: Fixed Interval Trial 2

12. Click on Resume.

The recording will continue from the point it last stopped, and a marker labeled “repeat fixed-interval” will automatically be inserted when Resume is pressed.

You will record a second fixed-interval presentation trial.

As soon as you hear each click through the headphone, press and release the push-button switch on the SS10L.

The recording will suspend automatically after ten clicks.

13. Subject should **press and release** the push-button switch on the SS10L at the sound of each click.

14. **Review** the data on the screen.

   - If correct, go to Step 15.
   - If incorrect, click Redo.

After 10 clicks, the resulting graph should resemble Fig. 11.4 above.

Data would be incorrect for the same reasons as with Fig. 11.4. To redo, click Redo and repeat Steps 12-14.

15. Click Done.

When you click Done, a pop-up window with four options will appear. Make your choice, and continue as directed.

If choosing the “Record from another Subject” option, remember that each Subject will need to use a unique file name.

16. Unplug the hand switch and headphones.

END OF RECORDING
V. DATA ANALYSIS

FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode.

2. Setup your display window for optimal viewing of the first marker and pulse of the first segment (Fig. 11.6).

Detailed Explanation of Data Analysis Steps

Enter **Review Saved Data** from the Lessons menu.

![Graphical illustration](image)

**Fig. 11.5 Reaction times for pseudo-random trial**

**Note:** Following the press of the **Done** button in previous section, the program automatically calculated all 10 reaction times and average reaction times for each trial and placed them in the journal (Fig. 11.4). Use this journal information to fill in your data report.

![Graphical illustration](image)

**Fig. 11.6 First marker and pulse segment**

The following tools help you adjust the data window:

- Autoscale horizontal
- Horizontal (Time) Scroll Bar
- Autoscale waveforms
- Vertical (Amplitude) Scroll Bar
- Zoom Tool
- Zoom Previous

Data Analysis continues…
3. Set up the measurement boxes as follows:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 1</td>
<td>ΔT</td>
</tr>
<tr>
<td>CH 1</td>
<td>none</td>
</tr>
<tr>
<td>CH 1</td>
<td>none</td>
</tr>
<tr>
<td>CH 1</td>
<td>none</td>
</tr>
</tbody>
</table>

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click on them.

A brief description of these measurements follows.

ΔT: The Delta Time measurement is the difference in time between the end and beginning if the selected area, which is the duration of the selected area.

none: turns the measurement channel off.

4. Select an area from the first marker to the leading edge of the first pulse (Fig. 11.7) and note the ΔT measurement.

5. Look at the first reaction time result in the Journal and compare this to the ΔT measurement found above.

6. Repeat the steps above on other pulses until you are convinced that the Journal readings are accurate.

The three sections are pull-down menus that are activated when you click on them.

Note: You can move around using the marker tools.
7. Transfer your data from the Journal to the Data Report.

   B

8. Collect data from at least five other students in your class as needed to complete the Data Report.

   C, D, E

9. Save or print the data file.

10. Exit the program.

   END OF DATA ANALYSIS

This step may not be necessary if your Instructor allows you to print out your Journal and staple it to the Data Report.

You may save the data to a floppy drive, save notes that are in the journal, or print the data file.

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**END OF LESSON 11**

Complete the Lesson 11 Report that follows.
Lesson 11

REACTION TIME

DATA REPORT
Student’s Name: ________________________________
Lab Section: ________________________________
Date: ________________________________

I. Data and Calculations

Subject Profile

Name ________________________________
Age ________________________________
Gender: Male / Female

Height ________________________________
Weight ________________________________

A. Manual calculation of reaction time

Calculate the reaction time for the first click in Segment 1: \( \Delta T = \) ________

B. Summary of Subject’s Results (copy from the software Journal)

Table 11.1

<table>
<thead>
<tr>
<th>STIMULUS NUMBER</th>
<th>REACTION TIMES (ms)</th>
<th>Fixed Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pseudo Random</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Segment 1</td>
<td>Segment 2</td>
</tr>
<tr>
<td></td>
<td>(1st trial)</td>
<td>(2nd trial)</td>
</tr>
<tr>
<td>1</td>
<td>Segment 3</td>
<td>Segment 4</td>
</tr>
<tr>
<td></td>
<td>(1st trial)</td>
<td>(2nd trial)</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C. Comparison of reaction time to number of presentations

Complete Table 11.2 with data from the first fixed-interval trial (data Segment 3) and calculate the mean for each presentation to determine if reaction times vary as the Subjects progress through the series of stimulus events.

<table>
<thead>
<tr>
<th>Student’s Name</th>
<th>Pseudo-random Trial 1 Data (Segment 1)</th>
<th>Fixed Interval Trial 1 Data (Segment 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stimulus 1</td>
<td>Stimulus 5</td>
</tr>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculate the Means:

D. Group Summary

Complete Table 11.3 with the mean for 5 students and calculate the group mean.

<table>
<thead>
<tr>
<th>Class Data</th>
<th>Pseudo-random trials</th>
<th>Fixed-interval trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Means</td>
<td>First</td>
<td>Second</td>
</tr>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculate the Group Means:

E. Variance and Standard Deviation

\[
\text{Variance} = \frac{1}{n-1} \sum_{j=1}^{n} (x_j - \bar{x})^2
\]

\[
\text{Standard Deviation} = \sqrt{\text{Variance}}
\]

Where

- \( n \) = number of students
- \( X_j \) = mean reaction time for each student
- \( \bar{X} \) = Group mean (constant for all students)
- \( \sum_{j=1}^{n} \) = Sum of all student data
Calculate the variance and standard deviation for 5 students with data from **Segment 2: Pseudo-random Trial 2** (Table 11.4) and from **Segment 4: Fixed Interval Trial 2** (Table 11.5).

**Table 11.4 Segment 2: Pseudo-random Trial 2 Data**

<table>
<thead>
<tr>
<th>Student</th>
<th>ENTER</th>
<th>ENTER</th>
<th>CALCULATE</th>
<th>CALCULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Reaction time for Student $(X_j)$</td>
<td>Group Mean $(X)$</td>
<td>Deviation $(X_j - X)$</td>
<td>Deviation$^2$ $(X_j - X)^2$</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sum the data for all students $\sum_{j=1}^{n} (x_j - \bar{x})^2$ =

Variance $(\sigma^2)$ = Multiply by 0.25 $\frac{1}{n-1}$ =

Standard Deviation = Take the square root of Variance $\sqrt{\text{Variance}}$ =

**Table 11.5 Segment 4: Fixed Interval Trial 2 Data**

<table>
<thead>
<tr>
<th>Student</th>
<th>ENTER</th>
<th>ENTER</th>
<th>CALCULATE</th>
<th>CALCULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Reaction time for Student $(X_j)$</td>
<td>Group Mean $(X)$</td>
<td>Deviation $(X_j - X)$</td>
<td>Deviation$^2$ $(X_j - X)^2$</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sum the data for all students $\sum_{j=1}^{n} (x_j - \bar{x})^2$ =

Variance $(\sigma^2)$ = Multiply by 0.25 $\frac{1}{n-1}$ =

Standard Deviation = Square root of Variance $\sqrt{\text{Variance}}$ =
II. Questions

F. Describe the changes that occurred in the mean reaction time between the 1st and 10th stimuli presentation:

For Segment 1:

For Segment 2:

Which segment showed the greatest change in mean reaction time?  Segment 1  Segment 2

G. Refer to Table 11.2 and Table 11.3:

Estimate the minimal reaction time when reaction time becomes constant: ________ sec

What physiological processes occur between stimuli presentation and pressing the hand switch? ____________________________

H. Refer to Table 11.2:

Which presentation schedule had a lower group mean? Pseudo-random  Fixed-interval

I. Refer to Table 11.2 and Table 11.3:

Which of the presentation schedules seems to have less variation (lower variance and lower standard deviation)? Pseudo-random  Fixed-interval

J. Refer to Table 11.2 and Table 11.3:

State a plausible relationship between the difficulty of a task and the reaction time statistics: mean, variance, and standard deviation.

K. What differences would you predict in reaction times and learning between your right and left hands? ____________________________

End of Lesson 11 Data Report