Reaction Time

Introduction

Consider an object, initially at rest, falling under the influence of gravity in the absence of air resistance. The distance d that the object falls in time t is given by

$$d = \frac{1}{2}gt^2 \,, \tag{1}$$

where g ($g = 9.80$) is the acceleration of gravity. Solving for t we obtain

$$t = \sqrt{\frac{2d}{g}} \,. \tag{2}$$

Figure 1: Equipment for Measuring Reaction Time

In this experiment reaction time is measured by two methods. In the first method, which is the less sophisticated, reaction time is determined indirectly using equation 2 and without the use of a chronometer. In the second method reaction time is measured directly using a stop watch which measures time accurate to milliseconds.

Figure 2: Method I

Procedure

Method I

While your partner holds a meter stick, you align your thumb and index (or middle) finger at some location on the meter stick, as shown in Figure 2. Your partner now releases the meter stick, allowing it to fall freely. As soon as the meter stick is released, you immediately attempt to catch the meter stick between your thumb and index finger. Record the distance through which the meter stick drops in Table 1. Perform the experiment nine additional times.

Method II

Holding the stopwatch in your hand and using your thumb, start and stop the watch as quickly as possible. Record the elapsed time in Table 2. Perform the experiment nine additional times.

Analysis

Method I

For the data in Table 1 calculate the average reaction distance $\bar{x}$, its standard deviation σ_{N-1}[1], and the standard deviation of the mean σ. The quantities $\bar{x}$ and σ_{N-1} can be calculated using function keys on a calculator or library functions in Excel. The quantity $\sigma = \sigma_{N-1}/\sqrt{N}$, where N is the number of measurements. Report these

[1]Note: there are two different standard deviations that are commonly used. The one being used here, statistically, is referred to, as the unbiased estimate of the standard deviation of the population.

calculations in Table 1 in the form $\bar{x} \pm \sigma$. The reaction time is now determined as follows. Using equation 2, calculate the quantities t, t_+, and t_-,

$$t = \sqrt{\frac{2\bar{x}}{g}}\,, \tag{3}$$

$$t_+ = \sqrt{\frac{2(\bar{x}+\sigma)}{g}}\,, \tag{4}$$

and

$$t_- = \sqrt{\frac{2(\bar{x}-\sigma)}{g}}\,. \tag{5}$$

The value t represents the best estimate of reaction time based on the data. The quantities t_+ and t_- define a range of times within which, according to the statistics, the true reaction time is most likely to lie. Report t, t_+, and t_- in Table 3.

Method II

For the data in Table 2 calculate the average reaction time $\bar{t}$, its standard deviation σ_{N-1}, and the standard deviation of the mean σ. Report these calculations in Table 2 in the form $\bar{t} \pm \sigma$. In this case t, t_+, and t_- are given by $t = \bar{t}$, $t_+ = \bar{t} + \sigma$, and $t_- = \bar{t} - \sigma$. Report t, t_+, and t_- in Table 3.

Conclusions

Do the two methods yield reaction times which are consistent with each other? An informal criterion for assessing consistency is: if the range of reactions times t_- to t_+ for the two methods overlap, then the two methods are consistent; otherwise, they are inconsistent. Should it be expected that the two different methods necessarily yield consistent results? Does it seem reasonable that reaction time may depend on how it is measured?

If you have a dollar bill or some other denomination, perform the experiment one more time with the dollar bill replacing the meter stick. Require that your partner align thumb and index finger with the middle of the dollar bill. Based on your knowledge of your partner's reaction distance, conjecture whether half the length of the dollar bill is sufficient for your partner to catch the dollar bill. Now, test your conjecture by performing the experiment!

Trial	d (m)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
$\bar{x} \pm \sigma$	$\pm$

Table 1: Data – Method I

Trial	t (s)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
$\bar{t} \pm \sigma$	$\pm$

Table 2: Data - Method II

	Method I	Method II
t		
t_-		
t_+		

Table 3: Comparison of Models I and II