Reaction time

NAME ______________________________ DATE ________________________

A hand accidentally touches the hot plate of an oven and is withdrawn immediately. A young child runs out in front of your car and you hammer on the brakes. A lottery ball falls into its position upside down and you have to shout out the correct number as fast as you can to a colleague who is checking off the numbers for your syndicate. All three examples of reaction time are the time it takes to make a movement in response to a sensory stimulus. However, even if we try to respond as fast as possible in each situation, the reaction time is quite different.

In this context, time is measured in milliseconds (ms) — thousandths of a second. It may take only 100 ms to withdraw our hand from the stove, 200 ms to stamp on the brakes, and 500 ms to read out the number on the ball. The difference occurs because of the different amount of time it takes for the central nervous system (CNS) to process the sensory signals and to choose the appropriate course of action.

The quickest reaction times have the simplest neuronal circuitry. Tap the knee and the leg moves. This is the tendon jerk beloved of clinical neurologists. The tap excites receptors in the quadriceps muscle at the front of the thigh and these send signals back to the lumbar part of the spinal cord. There, a direct connection is made to the motor neurons that innervate the quadriceps muscle and cause it to contract, making the leg kick forwards. It takes a total of about 30 ms for this to happen. The receptors take 1-2 ms to respond, and another 1-2 ms is needed for the connections to operate in the spinal cord. The remaining 27 ms or so is taken up with the time it takes nerve impulses to travel from muscle to spine and back again. There is of course a price to pay for such a fast circuit. The circuit is so simple that the same thing happens every time the tendon is tapped; it is impossible to control what happens no matter how hard we try. Because of this we refer to this type of reaction as a reflex, and the time it takes as the reflex response time.

MATERIALS

- Pencil
- Chair
- Ruler

PROCEDURES

1. **The subject marks a pencil line down the centre of his thumb-nail and sits sideways at a bench or table with the forearm resting flat on the bench and the hand over the edge (Fig. 1).**
2. The experimenter holds a ruler vertically between the subject's first finger and thumb with the zero opposite the line on the thumb but not quite touching either the thumb or fingers.
3. The subject watches the zero mark and, as soon as the experimenter releases the ruler, the subject grips it between finger and thumb to stop it falling any further.

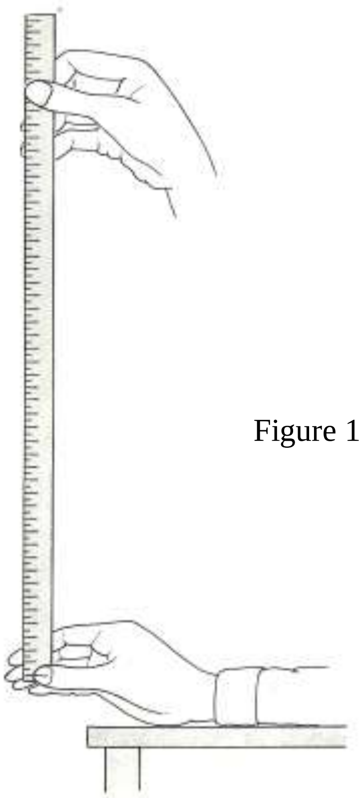

Figure 1

The distance on the ruler opposite the mark on the thumb is recorded in column 1 of Table 1.

4. This is repeated 4 times and the average distance calculated. This distance can be converted to a time by consulting Table 3.

5. The ruler is now used to measure the distance from the subject's eye to the base of the neck and along the arm to the middle of the forearm. This is recorded in column 1 of Table 1.

6. The experiment is now repeated with the same subject but this time the subject lets the ruler rest lightly against the thumb or fingers, with closed eyes, and grips the ruler as quickly as possible after he or she feels it begin to fall. The experiment is repeated 4 times and the results recorded in column 2 of Table 1.

7. The total distance is measured from the finger-tips to the head, and the head to forearm, and recorded in column 2 of Table 1

8. Collect the reaction times for your class and calculate the average in both cases.

Table 1			
Speed of response to sight		Speed of response to touch	
1		1	
2		2	
3		3	
4		4	
Total		Total	
Average		Average	
Time		Time	
Distance (nerve pathway)		Distance (nerve pathway)	

Table 2			
Reaction times: class results			
sight		touch	
Total		Total	
Average		Average	

Table 3				
distance in cm	time in seconds		distance in cm	time in seconds
1	0.045		21	0.207
2	0.064		22	0.212
3	0.078		23	0.217
4	0.090		24	0.221
5	0.102		25	0.226
6	0.111		26	0.230
7	0.120		27	0.235
8	0.128		28	0.239
9	0.136		29	0.243
10	0.143		30	0.247
11	0.150		31	0.252
12	0.156		32	0.256
13	0.163		33	0.260
14	0.169		34	0.263
15	0.175		35	0.267
16	0.181		36	0.271
17	0.186		37	0.275
18	0.192		38	0.278
19	0.197		39	0.282
20	0.202		40	0.286

DISCUSSION

1. Was there a significant difference in reaction times using sight and touch (a) for your own results, (b) for the class results when averaged?

2. The nervous pathway for the motor impulses from brain to forearm was probably the same for both experiments but the sensory pathway from eye to brain was much shorter than from finger-tips to brain. What differences in results would this lead you to expect?

3. State whether you think the class results fulfilled this expectation. If they did not, discuss possible reasons for their not doing so.

4. Assuming, for the moment that, in the touch experiment, the time of reaction is the same as the time taken for the nerve impulse to travel from the sensory organs in the finger-tips to the brain and back to the forearm, calculate the speed of conduction, in cm per second, of the nerve impulse by dividing the distance travelled by the reaction time.

5. The conduction velocity of nerve impulses in, mammalian nerve fibres ranges from 2 to 100 m per second. Your results are probably about 5 to 15 m per second. What are the faults in the assumption made in question 4 that might account for this low value?

6. Although it was the fingers which gripped the ruler, you were told to measure the distance to the forearm. Why was this?

Discussion - *answers*

1. The average class results will probably not show any significant difference (at the 5% level of confidence if analysed statistically) between the reaction times. These are likely to be in the region of 0.2 seconds in both cases.

2. The shorter sensory pathway from eyes to brain might lead one to expect a reduced reaction time.

3. The class results are unlikely to fulfil this expectation. The most likely reason is that the speed of conduction is so rapid that very large differences in distance would be needed to produce a measurable difference in reaction time by our crude methods. Other possibilities are that the touch receptors respond more rapidly than the retinal receptors and so compensate for the longer nervous pathway to be traversed, or that more synapses are involved in the optical pathway.

4. Conduction velocities will probably appear to be from 500 to 1500 cm per second.

5. The assumption that the reaction time can be attributed to the speed of conduction of nervous impulses ignores the other causes of delay, particularly the time taken for the muscles to contract on receiving an impulse. Transduction delays at receptors or synapses will also occur.

6. The muscles which operate the digits are mainly in the forearm and not in the digits themselves.