

Reaction time

Plan and carry out an investigation into the effect of a factor on human reaction time.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. Teacher answers start on a new page.

Name

Date

Aim

To find the effect of a distraction on the time it takes a person to catch a falling ruler.

Background

Reaction time is the time between a **stimulus** and the response. In this practical the stimulus is the ruler starting to fall and the response is the hand closing to catch it.

The signal travels along a pathway: a **receptor** (the eye) detects the stimulus, a **sensory neurone** carries impulses to the **central nervous system**, a **relay neurone** passes the message on, and a **motor neurone** carries impulses to an **effector** (the muscles in the hand). The response is **voluntary**, so the brain is involved.

You cannot easily time a reaction with a stopwatch, because your own reaction time to the stopwatch gets in the way. A falling ruler solves this: the further the ruler falls before it is caught, the longer the reaction time. Conversion from distance to reaction time (the time an object takes to fall that distance, using $g = 9.8 \text{ m/s}^2$): 10 cm = 0.14 s, 15 cm = 0.17 s, 20 cm = 0.20 s, 25 cm = 0.23 s, 30 cm = 0.25 s. For distances in between, read between the values.

Many factors could affect reaction time, such as caffeine, a distraction, practice, tiredness or which hand is used. You choose one factor to change and keep everything else the same.

Hypothesis

Reaction time will be longer when the volunteer is distracted, because the brain has to deal with another task at the same time, so the ruler will fall further before it is caught.

Variables

Independent	Whether the volunteer is distracted (counting backwards) or not
Dependent	Distance the ruler falls before it is caught (cm), converted to reaction time (s)
Control	• Same volunteer and same hand for every test • Same ruler and same starting position (zero at the top of the volunteer's thumb and finger) • Same person dropping the ruler, from the same height • Same way of reading the result (top of the thumb) • Same time of day and the same rest between tests

Equipment

- 30 cm ruler (a 1 m metre rule can also be used)
- Chair and a table with a clear edge
- Pen and results table
- Calculator
- Conversion table for distance to reaction time (given in the background above)

Risk assessment

Hazard	Risk	Precaution
Falling ruler	Minor bruise or pinch to fingers	Use a light plastic or wooden ruler and drop it from a low height. Keep fingers clear of the edge of the table.
Chairs and trailing bags	Tripping over bags or falling off a chair when lunging for the ruler	Sit with feet flat on the floor and keep the area around the table clear.
Human volunteers	A volunteer may be pressured, or may be unwell or allergic if a food or drink is used as a factor	Volunteers must agree freely and may stop at any time. Do not use caffeine drinks or other substances unless your teacher has approved it and consent has been given.

Method

1. Choose the factor to change. In this version the factor is a distraction: the volunteer counts backwards in threes aloud while trying to catch the ruler.
2. The volunteer sits with their forearm resting on the table and their dominant hand over the edge, thumb and forefinger about 1-2 cm apart.
3. The partner holds the ruler vertically so that the zero mark is level with the top of the volunteer's thumb.
4. The volunteer watches the ruler, ready to catch it.
5. Without warning, the partner lets go of the ruler. The volunteer catches it by closing the thumb and finger as fast as possible.
6. Read the distance on the ruler at the top of the volunteer's thumb and record it in cm.
7. Repeat 5 times with no distraction. Change the time before each drop each time so that the volunteer cannot predict it. Allow a short rest between drops.
8. Now the volunteer counts backwards in threes aloud from 100 while the partner drops the ruler without warning.
9. Record the distance and repeat 5 times with the distraction.
10. Calculate the mean distance for each condition.
11. Use the conversion table to change each mean distance into a reaction time in s.
12. Swap roles, or collect class data, so that results from several volunteers can be compared.

Results

Distance the ruler fell before it was caught							
Condition	Test 1 (cm)	Test 2 (cm)	Test 3 (cm)	Test 4 (cm)	Test 5 (cm)	Mean distance (cm)	Reaction time (s)
No distraction							
Counting backwards							

Graph

Bar chart of mean reaction time in s (y-axis, labelled ‘Reaction time (s)’) against condition (x-axis, one bar for ‘No distraction’ and one for ‘Counting backwards’). Bars of equal width with gaps between them, because the independent variable is a category. Use more than half the grid and equal scale steps starting at zero.



Exam questions 10 questions · 26 marks

1 State the independent variable in the investigation described in the sample results. [1 mark]

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2 Give two variables that the students should control in this investigation. [2 marks]

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3 Explain why the partner drops the ruler without warning. [2 marks]

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- 4** A volunteer caught the ruler after it had fallen the distances shown in the table. One result is anomalous. Identify the anomalous result and calculate the mean of the other results. **[3 marks]**

Distance the ruler fell						
Test	1	2	3	4	5	6
Distance (cm)	22	19	21	35	20	23

Answer =

- 5** Describe the pathway taken by impulses from the eye to the hand when a person catches a falling ruler. Use words from the box. effector, motor neurone, receptor, relay neurone, sensory neurone, central nervous system **[3 marks]**

- 6** The student displays the mean reaction times for the two conditions on a chart. Name the type of chart that should be used and give a reason. **[2 marks]**

- 7** Use the sample results (mean reaction time 0.16 s with no distraction and 0.21 s when counting backwards) to calculate the percentage increase in reaction time caused by the distraction. Give your answer to 2 significant figures. **[3 marks]**

Answer =

8 Suggest one way to improve the accuracy of measuring reaction time in this investigation. [2 marks]

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9 Explain why the results from one volunteer cannot be used to make a conclusion about all students. **[2 marks]**

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10 A student thinks that drinking a caffeine drink will shorten a person's reaction time. Plan an investigation to test this using the ruler-drop method. Include how you would make the investigation safe and ethical. **[6 marks]**

[illegible]

Teacher answers

Required practical 7: Reaction time. The example results are practice data, not real measurements.

Example results

Example results (practice data). Reaction times from the conversion table: 13.0 cm is 0.16 s and 21.0 cm is 0.21 s.

Condition	Test 1 (cm)	Test 2 (cm)	Test 3 (cm)	Test 4 (cm)	Test 5 (cm)	Mean distance (cm)	Reaction time (s)
No distraction	12	14	13	15	11	13.0	0.16
Counting backwards	19	22	20	24	20	21.0	0.21

Conclusion

The mean distance the ruler fell was 13.0 cm with no distraction and 21.0 cm with the distraction. This is a reaction time of about 0.16 s compared with about 0.21 s. So the distraction **increased** reaction time, which agrees with the hypothesis. When the volunteer is counting, the brain has to process more than one task, so impulses from the eye to the muscles are dealt with more slowly. The results are from one volunteer only, so they do not show that everyone is affected in the same way.

Errors and improvements

Error	Effect on the results	Improvement
The volunteer predicts the drop (a systematic error that makes reaction time look too short).	The volunteer starts to close their fingers before the ruler moves, so the distance is too small.	The partner should drop the ruler without warning, and change the time before each drop.
The ruler is not released in the same way each time, or the zero is not level with the thumb.	The distance is read from a different starting point, adding random error to the results.	Check the zero is level with the top of the thumb each time, and use the same person to drop the ruler.
Practice: the volunteer gets quicker with each test.	Later tests are quicker whatever the condition, so the effect of the factor is mixed up with the effect of practice.	Give practice goes first, and alternate the order of the conditions.
Only one volunteer and only five repeats.	Results may not be typical of other people and anomalies have more effect on the mean.	Test several volunteers, take more repeats and ignore anomalous results when calculating the mean.
Reading the ruler to the nearest cm is not very precise at short distances.	A 1 cm error is a large fraction of a short distance.	Use a computer-based reaction timer, which measures to 0.001 s.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [1]

- whether the volunteer was distracted / counting backwards or not (1)

2. [2]

- same volunteer / same hand (1)
- same ruler / same person dropping the ruler / same height of drop / same starting position of the ruler / same time of day (1) allow any two sensible control variables

3. [2]

- so the volunteer cannot predict / anticipate the drop (1)
- so the result is a true measure of the reaction time / the volunteer does not start to close their hand early (1)

4. [3]

- 35 (cm) (1)
- $(22 + 19 + 21 + 20 + 23) \div 5$ (1)
- = 21 (cm) (1)

5. [3]

- receptor (in the eye) detects the stimulus (1)
- impulses along a sensory neurone to the central nervous system, where a relay neurone passes them on (1)
- impulses along a motor neurone to the effector (muscle in the hand), which contracts (1)

6. [2]

- bar chart (1)
- because the independent variable is a category / not continuous (1) allow because the conditions are separate groups

7. [3]

- $\text{change} = 0.21 - 0.16 = 0.05 \text{ s}$ (1)
- $0.05 \div 0.16 \times 100$ (1)
- = 31 % (1) an answer of 31.25 or 31.3 (not to 2 significant figures) scores 2 marks

8. [2]

- use a computer-based / electronic timer (1)
- which measures time directly to a smaller unit / removes the need to read a ruler (1)
- Max 2. allow for 1 mark: repeat with more volunteers and calculate a mean

9. [2]

- people differ / one person may not be typical (1)
- need a larger sample / several volunteers to show the same trend (1)

10. [6]

Level 3 5-6	A clear, logical plan with the independent variable (caffeine drink or a drink without caffeine as a control), the dependent variable (distance the ruler falls, converted to a time), at least three control variables, repeats with a mean, and at least one safety or ethical point. The plan could be followed by another person.
Level 2 3-4	A plan with most key steps. The independent and dependent variables are identified, but control variables, repeats or safety / ethics are weak or missing.
Level 1 1-2	A few simple points, for example 'drink coffee and catch a ruler', with no control or little detail.

Indicative content

- test the volunteer before drinking, then after a caffeine drink and wait for a set time (for example 20 minutes)
- use a control: the same volunteer drinks a drink with no caffeine on another day (or group), ideally without knowing which one it is
- ruler drop with the partner dropping without warning; record distance fallen in cm
- repeat at least five times for each condition and calculate a mean; ignore anomalies
- control volunteer, hand, ruler, drop height, time of day, amount of drink
- safety / ethics: informed consent, check for allergies or health conditions, limit the amount, volunteers can stop at any time, follow teacher approval

Exam tips

- A shorter distance means a faster reaction. Make sure your conclusion says 'reaction time increased / decreased', not just 'the distance changed'.
- Control variables must be specific: 'same hand' and 'same height of drop' score, 'keep it fair' does not.
- In planning questions, always include repeats and a mean. Say the partner drops the ruler without warning.
- Reaction is a voluntary response here, so the brain is involved. Do not describe it as a reflex.