Reaction times Teachers' Notes

Introduction

Experiments to test and compare reaction times offer opportunities for hypothesis testing and devising and setting up experiments in a scientific way to control as many variables as possible. A wide range of data handling skills at varying levels can be used to display and analyse the data and consider the significance of the results. *TI-Nspire* will display results in a variety of ways and provide a wide range of statistical calculations. This means that less experienced students can access statistical displays and measures to analyse in order to test their theories that might otherwise have been too complex or time consuming. The stages in the data handling cycle will require the students to:-

1. Pose a question about 'Reaction times' and plan how they will collect data to try to answer it.
2. Collect the data.
3. Represent and analyse their data.
4. Interpret and discuss their results.

Possible questions for students to think about.

1. What factors could influence reaction times? Which one(s) will you consider? What question will you ask?

At the planning stage students need to consider all the factors that might influence the results of their tests and what precautions they need to take to ensure that the test is the same for everyone taking it.

What data will you record, how will you record it?
How can you set up the experiment to collect the data and ensure that this data is reliable and not influenced by other factors?

2. Have you collected all the data you need? Were there any problems that might influence the results?
3. How will you enter the data into TI-Nspire and which features will you use to display and analyse your results?
4. What conclusions did you reach? Can you explain your conclusions to others using your display to back up your conclusions? Would you expect to get similar results if you repeated the experiment? Did you answer your original question or do you need to collect more data or repeat the experiment? Advanced level students could also consider the significance of their results.

Reaction times activity

1. Posing the question

There needs to be some initial whole group discussion about reaction times and the factors that might affect them. Ideally the class will suggest the factors that might influence reaction times, and then decide on a question that they would like their group to answer, bearing in mind the constraints of the individual classroom. These are some possible discussion points:-

- gender differences;
- preferred/ non- preferred hand;
- distractions e.g. noise, conversations ;
- alertness – time of day; before or after food, lack of sleep, after caffeine;
- do you get better if you practice with a particular test?
- do different tests produce similar results?
- do you need to have particularly good reactions to play some sports in which case do players of these sports perform better in reaction time tests?

Some examples:-

- The BBC programme 'Bang goes the theory' http://www.bbc.co.uk/bang/ has launched an experiment to collect data to see whether brain training exercises do really improve performance over a period of time. Amongst the tests they are trying are tests for 'Reaction times'.
- The BBC Science pages also have a reaction time test which is linked to a page about sleep and how sleep deprivation and also caffeine can affect reaction time. http://www.bbc.co.uk/science/humanbody/sleep/sheep/reaction_version5.swf
- Recent evidence suggests that driver's reaction times are affected if they are having a mobile phone conversation even if the phone is a hands-free one.
- Some internet reaction timers (see below) use different shapes or colours – do these influence the results? Most tests are initiated by the computer but the Nrich website test is initiated by the person being tested—does this make a difference? How do the ruler experiments compare?

2. Setting up the experiment and collecting the data.

These are some things that you might wish your students to consider when setting up their experiments.

- **Reproducibility** – What rules do you need to set to ensure the experiment is the same for everyone?
- **Reliability** – How reliable are your results? Would the same thing happen if the experiment was repeated?
- **Interaction** – How can you ensure that later people tested will not be influenced by what was done before?
- **Representative groups** – If a larger scale experiment is involved, how can you ensure that the sample you choose is really representative of the whole population?

2.1 Practical experiments using a ruler

The tester holds a ruler (30cm or longer) against a wall with the zero mark at the bottom. The person being tested puts a finger at the zero mark just clear of the ruler. The ruler is then dropped and has to be stopped by the outstretched finger. (There are pictures in the two examples below.)

The distance the ruler drops before it is stopped is then recorded. Repeat several times. What precautions do you need to take to ensure the results are fair? (See the notes above.)

This experiment measures reaction times using distances. These can be converted into times using an approximate rule that in t seconds the distance travelled $d = 5t^2$ metres. How will this help you to convert distances in centimetres into times in seconds? (See teacher's notes)

Practical Biology website http://www.practicalbiology.org/areas/intermediate/control-and-communication/reflex-actions/measuring-reaction-time-of-a-human-reflex-action,88,EXP.html gives details of a practical experiment in Biology using metre rules to compare reaction times before and after drinking caffeine.

The Royal Statistical Society's Centre for Statistical education (RSSCSE) has links in their resource section to activities from a Schools council project one of which is 'Reaction Times' under a general heading of 'Practice makes perfect'. http://old.rsscse.co.uk/pose/level1/book6/sectionb.htm

2.2 Internet Reaction Timers

There are several websites that will collect data on Reaction Times. These are quick to use so students working in pairs could collect their data one pair at a time using one computer in a classroom, while another activity was going on. They will need to make decisions on how many samples to take, whether to write each individual result down or whether to put the average of five, which some websites give. These are some examples.

1. **Sheep dash from BBC Science**
   http://www.bbc.co.uk/science/humanbody/sleep/sheep/reaction_version5.swf

On this website, which is part of the BBC websites Science section about sleep, you have to click the mouse when you see a sheep break for freedom. The average of five attempts is given. The times are given to one thousandth of a second which is a greater degree of accuracy than other web sites. [You may want to reach a collective decision about what to do with penalty results (3 seconds) for false starts as these can distort the data, but may be worth investigating separately. Sets of five which included penalty scores were ignored in the sample file shown below.] The idea on this Science section of the website is to see how factors such as drinking caffeinated drinks or lack of sleep affect reaction times.

2. http://getyourwebsitehere.com/jswb/rttest01.html
This reaction timer is a set of traffic lights set to red. Click when they change to green. Average of sets of five results is given.

3. http://www.mathsisfun.com/games/reaction-time.html
For this reaction timer you click when a small circle changes from yellow to red. Average of sets of five results.

4. NRich http://nrich.maths.org/public/viewer.php?obj_id=6044
For the NRich reaction timer you click the mouse to make a star disappear and then click again when it reappears. As you effectively choose the start time yourself for this reaction timer, does this produce different results from other timers?

5. Experiments at school
http://www.experimentsatschool.ntu.ac.uk/experiments/reaction/
has experiments to collect data but you can also download data sets from other schools or from different parts of the world.

3. Entering and displaying the data.

Ideally in this activity students will pose their own questions and collect appropriate data. How they choose to analyse and display their data will then depend on the question that they posed initially. There are notes in the introduction to this booklet about entering data and some forms of display. The notes for students at the end of this activity show examples of different forms of analysis and display with questions about these to help them get some ideas, but it is important to state that the examples of data collected for these examples is from too small a sample to provide valid conclusions.

4. Interpreting and discussing results.

Students need to analyse their results with regards to the question that they posed initially.

- Can they backup their findings with statistical displays and calculations?
- Would they expect to get similar results with a different group of people?
- How do their findings compare with others?
- Do they need to repeat the experiment under different or stricter conditions?

Additional notes for teachers

Distance-to-time conversion for ruler experiment.

If using the practical experiment with rulers the distances can be converted into times. Depending on the students you may want to do one or more of the following.

- Explain why the approximate rule $d = 5t^2$ works
  (**NB** *d* is in metres, *t* is in seconds and acceleration due to gravity g is taken as $10ms^{-2}$)

- Ask them to rearrange the rule so that *t* is the subject.

- Show them how to insert an extra column into the spreadsheet with a formula to change *d* into *t*.

Notes on displays featured in 'Further help for Students'

Quick graphs: The line shown has a very small negative gradient, which would suggest improvement over time but this needs discussing as pupils need to realise the dangers of extrapolating in this way.

Box plots: The **outlier** in the lower box plot- the person being tested using 'Sheep dash' reckoned that this was a fluke and that he had actually jumped the gun and made a false start for this score. He thought it was just luck as it was so close to the actual sheep leaving that with the mouse delay the computer hadn't picked it up. It should have given him a 3 second penalty.

Histograms: For more advanced students if more data is collected – how well does the data fit a normal distribution?

Analysis: It is a useful skill for students to be able to interpret the data table and select appropriate information such as