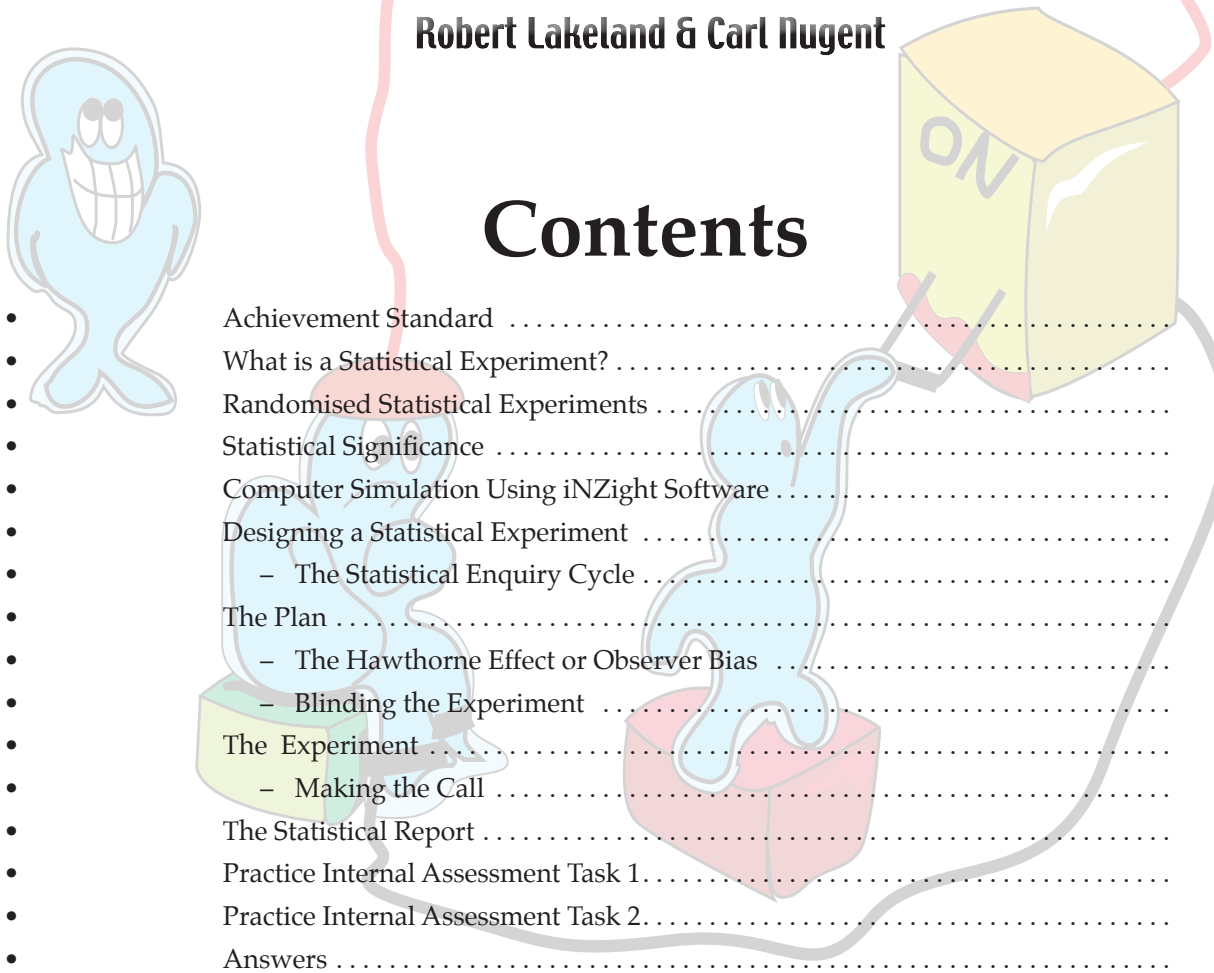
Year 13 Mathematics

IAS 3.11

Statistical Experiments

Robert Lakeland & Carl Nugent



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NCEA 3 Internal Achievement Standard 3.11 – Statistical Experiments

This achievement standard involves conducting an experiment to investigate a situation using experimental design principles.

Achievement	Achievement with Merit	Achievement with Excellence
• Conduct an experiment to investigate a situation using experimental design principles.	• Conduct an experiment to investigate a situation using experimental design principles, with justification.	• Conduct an experiment to investigate a situation using experimental design principles, with statistical insight.

- This achievement standard is derived from Level 8 of The New Zealand Curriculum and is related to the achievement objectives
  - Carry out investigations of phenomena, using the statistical enquiry cycle:
    - conducting experiments using experimental design principles
    - seeking explanations
    - using informed contextual knowledge, exploratory data analysis, and statistical inference
    - communicating findings and evaluating all stages of the cycle.
  - Make inferences from surveys or experiments:
    - using methods such as randomisation.
- Conduct an experiment to investigate a situation using experimental design principles involves showing evidence of using each component of the investigation process.
- Conduct an experiment to investigate a situation using experimental design principles, with justification involves linking components of the process of investigating a situation by experiment to the context, explaining relevant considerations in the investigation process, and supporting findings with statements which refer to evidence gained from the experiment.
- Conduct an experiment to investigate a situation using experimental design principles, with statistical insight involves integrating statistical and contextual knowledge throughout the investigation process, and may include reflecting about the process; discussing how possible sources of variation were dealt with during the design phase; considering other relevant variables.
- The process of investigating a situation by experiment using experimental design principles involves:
  - posing an investigative question about a given experimental situation
  - planning the experiment using experimental design principles
    - selecting experimental units
    - determining treatment and response variables
    - determining allocation of treatments to experimental units
    - determining data collection and recording methods
    - considering other sources of variation
  - conducting the experiment
    - collecting data
    - recording any issues that arise
  - selecting and using appropriate displays and summary statistics
  - making appropriate formal statistical inferences
  - communicating findings in a conclusion.

What is a Statistical Experiment?

Observational Studies and Statistical Experiments

In observational studies and statistical experiments we want to see if different inputs (called the **independent** or **explanatory** variable) results in some change in the outcome (called the **dependent** or **response** variable).

For example, if we wanted to study whether the consumption of caffeine drinks resulted in a change in the time to complete a task, then the consumption of caffeine would be the explanatory variable while the time to complete the task would be the response variable.

In an observational study we **observe** differences in the consumption of caffeine drinks (explanatory variable) to see if they are connected to differences in the time to complete the task (response variable).

In a statistical experiment we **create** differences in the consumption of caffeine drinks (explanatory variable) and see if these result in a change in the time to complete the task (response variable).

Observational Studies

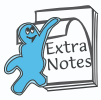
For an observational study we could ask the subjects how manny caffeine soft drinks (explanatory variable) they consumed and compare the results to the time to complete the task (response variable). One problem with observational studies is it could be that the sort of person who consumes large amounts of caffeine drinks tends to be faster at completing physical tasks. Both the caffeine drinking and speed to complete the task may depend on some other variable (e.g. genetics, skill etc.) and not on each other. This other variable is called a **lurking** or **confounding** variable.

Statistical Experiments

For a statistical experiment we could get half the subjects (called the **treatment** group) to consume caffeine drinks (explanatory variable) and measure the time to complete the task (response variable). So we have a basis for comparison we would get the other half of the subjects (the **control** group) to consume non-caffeine drinks and measure their time to complete the same task.

It could be that our two groups (treatment group and control group) were different in some respect and this difference resulted in different times to complete the task. To balanced inherent differences we randomly allocate subjects to the two groups. When we randomly allocate subjects, the subjects that are naturally fast at completing the task should be spread between the two groups.

We call this approach a **randomised statistical experiment.**



Statistics Glossary

The authors recommend you assemble your own statistics glossary as this Achievement Standard will examine your statistical literacy. Some terms will be defined in this workbook but a glossary you put together yourself would be even better as you could include terms you did not already know and assembling the glossary will help you remember them. Use Page 63 for YOUR statistics glossary.

Statistical Literacy

- **An Observational Study is one in which two groups are observed but there is no input or treatment imposed upon the subjects.**
- **An Experimental Study is one in which two groups are compared. One group is subject to a change or treatment and the other is not.**
- **The Explanatory (or treatment) Variable is a variable which is varied (treated) in an experiment or studied in an observational study to see if changes in the explanatory variable are connected to changes in an outcome.**
- **The Response (or dependent) Variable is the variable that is measured to assess the outcome.**
- **The Lurking or Confounding Variable is a variable that is not part of the study but effects the outcome or response variable.**
- **A Control group is a group in an experimental study that has no change or treatment of the explanatory variable imposed upon it.**
- **A Randomised Experiment is when the subjects or participants are allocated randomly to the two groups to minimise the effect of other variables.**

Computer Simulation Using iNZight Software

Downloading the Software from the iNZight Website

A good demonstration of randomisation is part of the iNZight package. First you must get your own copy of the software.

This statistics package is available for free.

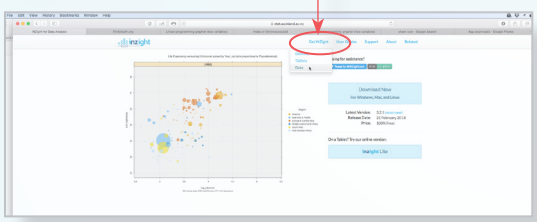
Search on the internet for iNZight.

Select 'Download Now' and then your operating system, Windows or Mac.

Download your selection and open the folder. It does not install like a conventional programme. There is a module for updating the software as it is further developed and another for running the programme.

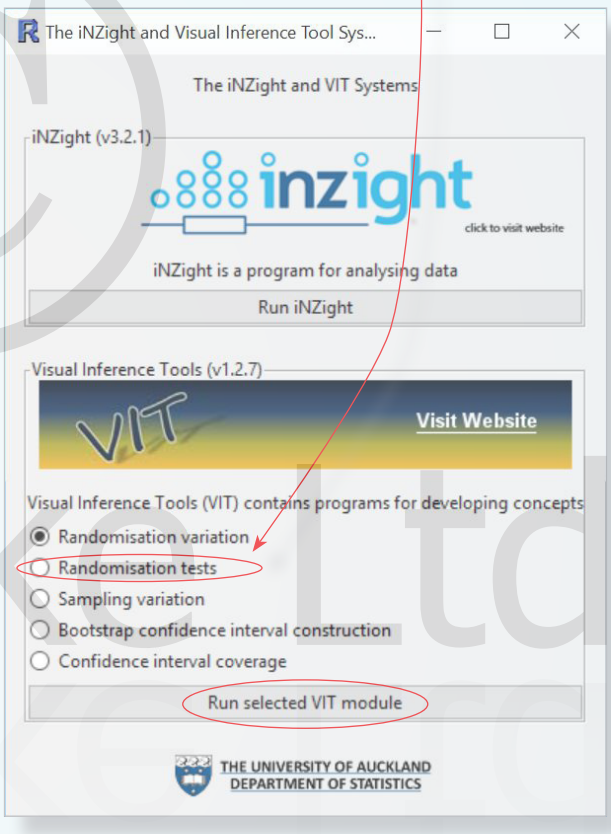
There is a video for Mac users as it may not be straightforward.

There is also a folder of data which we will use. Click 'Get iNZight' at the top and then select data. Rename and move the data folder to your documents folder.

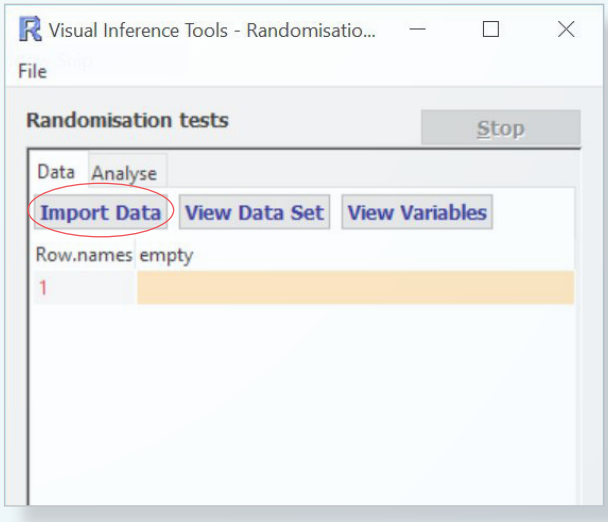


After installation run the VIT programme (Visual Inference Tools) which loaded at the same time as iNZight. The first time of operation takes a while to load but it should be quicker after this.

When the Menu loads up select 'Randomisation tests' and 'Run selected VIT module'.



The Randomisation tests loads up but we must import some data.

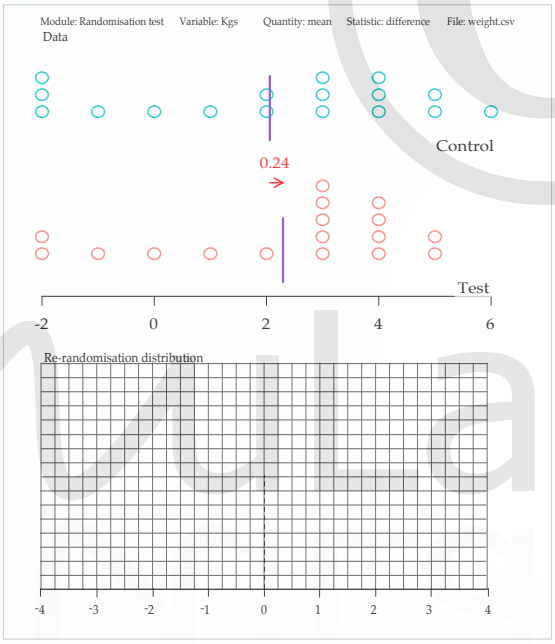


Acknowledgements

The software was developed by a team led by Chris Wild of the Statistics Department of the University of Auckland. Work on programme infrastructure was begun by Garrett Grolemund (Rice University, who also came up with the name "Visual Inference Tools") and continued by Ben Stevenson and Simon Potter of the University of Auckland who have also done all of the programming of the modules.

3. The school guidance counsellor was concerned that many students were purchasing a weight control pill that science teachers claimed could not possibly work. She collected some volunteers who wanted to lose weight. She randomly assigned them into two groups. One she gave the pill to and the other she gave a sugar (placebo) pill. This was the control group. For four weeks she met with both groups and had the same support sessions with each group. After the four weeks the weight loss of each group is as shown. The results are in the file weight.csv.

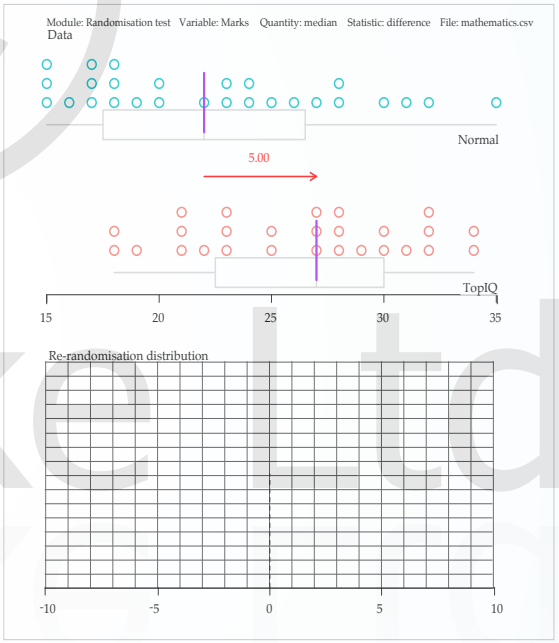
a) Run the VIT module Randomisation test for weight.csv for the difference in the means. Sketch the results including the tail proportion here.



b) On the basis of the 1000 random samples, is there sufficient evidence to eliminate chance alone as the sole reason there is a difference in weight lost between the control group and the test group? Justify your answer.

4. To illustrate how teacher perceptions affect student results a Principal gained permission to randomly allocate some students to two mathematics classes to be taught by the same teacher. The mathematics teacher of both classes was told one group was a normal class (labelled control in your data) and the other is a group of high IQ but possibly lazy students (called TopIQ in your data). IQ or intelligence quotient is a contentious measure of 'intelligence'. The teacher taught both groups over the same time period and administered the same test. The results are in the file mathematics.csv.

a) Run the VIT module Randomisation test for mathematics.csv for the difference in the medians. Sketch the results including the tail proportion here.



b) On the basis of the 1000 random samples, is there sufficient evidence to eliminate chance alone as the sole reason there is a difference between the marks for the two parallel classes? Justify your answer.

Achievement – Undertake the experiment, record the results and then save them as a CSV file. Use the iNZight VIT Randomisation test module to analyse the results and sketch graphs of the results. Draw conclusions based on the analysis and observations of the experiment.

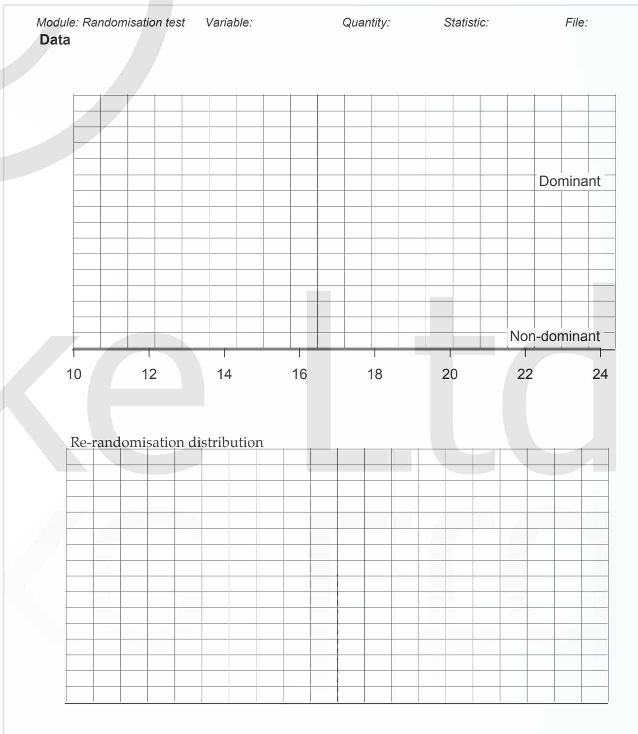
15. Does the reaction time of a hand depend upon whether the dominant hand (left or right) is used? Repeat and if possible improve upon the experiment on dominant versus non-dominant hand reaction time. This is the experiment already described in the example.

a) Carefully describe your experiment and raw data along with appropriate graphs. Can you draw a conclusion on the basis of your experiment? The ruler for measuring reaction time is available in the Statistical Experiments Dataset for IAS 3.11 downloadable from the NuLake website.

b) Conduct the experiment and record the results.

Hand	Time

c) Use Excel to make a CSV file. Save using 'File / Save As' then Comma Separated Values (CSV). Import your CSV file into iNZight's Randomisation test module and analyse the mean or median difference in the reaction time for each hand. Sketch a copy of the graph and proportion on the bank graph.



d) Is there sufficient evidence to eliminate chance alone as the sole reason there is a difference between the reaction time of the dominant and non-dominant hands? Justify your answer.

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Practice Internal Assessment Task 1

Statistical Experiments 3.11

Chewing gum is banned in most schools but some researchers believe it can help students concentrate on tasks. This assessment requires you to produce a report describing an experiment investigating chewing in the classroom. You must research the situation, pose an investigative question, plan, and carry out your experiment, analyse the data from your experiment, make an appropriate formal statistical inference, and write your report.

This activity requires multiple sessions to complete the investigation. You are expected to use iNZight software as part of the analysis of the data.

ScienceDaily
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Web address:
http://www.sciencedaily.com/releases/2013/03/130308093933.htm

Chewing Gum Helps You Concentrate for Longer, Study Suggests

Mar. 8, 2013 — Chewing gum can help you stay focused for longer on tasks that require continuous monitoring. This is the finding of new research by Kate Morgan and colleagues from Cardiff University due to be published in the *British Journal of Psychology* today, 8 March.

Chewing gum can help you stay focused for longer on tasks that require continuous monitoring. (Credit: © nyul / Fotolia)

Previous research has shown that chewing gum can improve concentration in visual memory tasks. This study focussed on the potential benefits of chewing gum during an audio memory task.

Kate Morgan, author of the study explained: "It's been well established by previous research that chewing gum can benefit some areas of cognition. In our study we focussed on an audio task that involved short-term memory recall to see if chewing gum would improve concentration; especially in the latter stages of the task."

The study involved 38 participants being split in to two groups. Both groups completed a 30 minute audio task that involved listening to a list of numbers from 1-9 being read out in a random manner. Participants were scored on how accurately and quickly they were able to detect a sequence of odd-even-odd numbers, such as 7-2-1. Participants also completed questionnaires on their mood both before and after the task.

The results showed that participants who chewed gum had quicker reaction times and more accurate results than the participants who didn't chew gum. This was especially the case towards the end of the task.

Kate explained: "Interestingly participants who didn't chew gum performed slightly better at the beginning of the task but were overtaken by the end. This suggests that chewing gum helps us focus on tasks that require continuous monitoring over a longer amount of time."

Source: Science Daily 10 March 2013

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11. Purple may be a favourite or least favourite colour. Give a small questionnaire to find the least and most favourite colour. The confounding variables may be:

- Likes purple
- Dislikes purple

Design. Divide the participants up into blocks, likes purple, dislikes purple or no opinion of purple.

Randomly allocate the participants in each block to the control and treatment groups so there is an even number of participants from each block in each of the two groups. Tell both groups that they are to taste a new cordial developed at school and need to rate it from 1 horrible to 10 great. This way they do not know that the experiment is about colour and not taste (single blind).

12. Some students may dislike the taste of sports drink or fruit juice. The possible confounding variables may be:

- Dislikes sports drinks
- Dislikes fruit juice.

Design. Ask beforehand how often they have either sports drink or juice and divide the participants into blocks. Lower frequency sports drink in one block, lower frequency fruit juice in the second and the rest in the third block.

Randomly allocate the participants in each block to the control and treatment groups so there is an even number of participants from each block in each of the two groups.

A potentially better way is to use the same drink for both groups and add some caffeine to the treatment drink. It is unlikely that a school will allow students to add caffeine to a drink but they may allow them to drink a sports drink containing caffeine.

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13. Both groups will be told to record the time taken and who got how many sticks but the time taken is the response variable. The confounding variables may be:

- Gender. Maybe one sex is more competitive than the other.
- Degree of socialisation. Will social isolates be more or less competitive?

Design. Ask them beforehand how many of the forty participants they know.

Then divide them into blocks by gender and then further divide each blocks by whether they know more or less than five participants.

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Randomly allocate the participants in each block to the control and treatment groups so there is an even number of participants from each block in each of the two groups. Tell the control group to pair up with someone in their group. The control group will be told to work together to collect the sticks while sticking to the rules. The treatment group will also be told the total time is important and which of them has the most sticks is important. This way they do not know that the experiment is just about time (single blind).

14. The possible confounding variables may be:

- Gender
- Part time job.

Design. Ask beforehand whether they have a part time job and then divide the group into two blocks based on gender and further divide the two blocks based on the part time work.

Randomly allocate the participants in each block to the control and treatment groups so there is an even number of participants from each block in each of the two groups. Tell both groups this is an exercise in how people spend large amounts of money. This way they do not know that the two groups are getting different instructions (single blind).

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15. a) Five individuals should each be tested three times with dominant hand and non-dominant hand. The hand tested would be decided randomly for each drop.

The hand would rest on a flat surface (so it could not drop with the ruler) and the thumb and forefinger would be 20 mm apart. The time for release would be varied without any pattern from 5 to 30 seconds.

b) As this is an experiment the results will vary.

c) The results will vary but a dot plot and histogram of differences should be given along with the proportion of differences greater than the experiment results.

d) If the proportion is greater than 0.1 (10%) then we can state that we have no evidence against chance acting alone in this experiment. If the proportion is less than 0.1 (10%) then we can conclude that we have evidence that chance is not acting alone and the dominance of the hand affects the reaction time.