Basic Inferential Statistics Cheat Sheet

	Purpose	Example H_0	Function	Visualising§	Non-parametric analogue	Function
Student's *t*-test	To compare 1 or 2 means.					
One-sample t-test	Compare the mean of 1 sample to an expected theoretical value.				One-sample Wilcoxon Signed-rank Test.	
One-sided		The growth rate of a sample of soya bean sprouts is not larger than 0.	`t.test(x, mu = 0, alternative = "greater")` where x is continuous (integer or double)	None.		`wilcox.test(x, alternative = "greater", mu = 0)`
Two-sided		The growth rate of a sample of soya bean sprouts is not different from 0.	`t.test(x, mu = 0)` where x is continuous (integer or double)	None.		`wilcox.test(x, mu = 0)`
Two-sample t-test	Compare the mean of a sample to the mean of a second independent sample. It asks if the difference in means is significantly different from 0.				Two-sample Mann-Whitney U Test.	
One-sided		The height of women in the BCB744 class is not less than that of men in the same class.	`t.test(x, y, alternative = "less")` where x, y are continuous (integer or double)	Bar graph ± SD, or box and whisker plot, but typically not necessary.		`wilcox.test(x, y, alternative = "less")`
Two-sided		The height of women in the BCB744 class is not different from that of men in the same class.	`t.test(x, y)` where x, y are continuous (integer or double)	Bar graph ± SD, or box and whisker plot, but typically not necessary.		`wilcox.test(x, y)`
Paired t-test	Compare the means of 2 samples sets of paired observations. It tests if the difference between pairs is significantly different from 0.					
One-sided		The body fat content of a sample of 10 mice fed only cheese does not increase over the space of a week.	`t.test(x, y, paired = TRUE, alternative = "greater")` where x is continuous (integer or double)	Line graph with whiskers (percentiles + bootstrapped CI), but typically not necessary.		`wilcox.test(x, y, paired = TRUE, alternative = "greater")`
Two-sided		The body fat content of a sample of 10 mice fed only cheese does not change over the space of a week.	`t.test(x, y, paired = TRUE)` where x, y are continuous (integer or double)	Line graph with whiskers (percentiles + bootstrapped CI), but typically not necessary.		`wilcox.test(x, y, paired = TRUE)`
ANOVA	Similar to a 2-sample, 2-sided *t*-test, but it can compare more than 2 groups of samples. It tests if the difference in means between >2 groups is different from 0.				Kruskal-Wallis Rank Sum Test.	
One-way	The measurement variable is distributed across >2 levels (e.g. donkey, cow, sheep dung) of 1 treatment (e.g. manure type).	The mass of 3 groups of cabbages fertilized with either donkey, cow, or sheep manure is not different after the experimental period.	`aov(y ~ x, data = data)` where y is continuous (integer or double) and x is categorical	Bar graph ± SD, or box and whisker plot.		`kruskal.test(y ~ x, data = data)`
Two-way (and more)	There are multiple (>1) factor variables, each with multiple levels. In the example there are 2 factor variables, *viz*. manure type and watering regime – the first has 3 levels, and the second 2 levels.	The mass of 6 groups of cabbages fertilized with either donkey, cow, or sheep manure **and** subjected to 2 watering regimes (twice and three times a week) is not different after the experimental period.	`aov(y ~ x + z, data = data)` where y is continuous (integer or double) and x and z are categorical	Grouped bar graph ± SD, or grouped box and whisker plot.	A two-way analysis on ranks is not recommended as it is not based on strong statistical principles.	NA
ANCOVA	Similar to a two-way ANOVA, but where the two-way ANOVA has >1 factor variables, an ANCOVA has 1 or more factor variables **as well as** a continuous covariate*.	Lung capacity is not affected by gender (the factor variable) or age (the continuous covariate).	`aov(y ~ x + z, data = data)` where y and z are continuous (integer or double) and x is categorical	Grouped simple linear regression lines with CI bands.	See under Simple Linear Regressions, below.	See below.
Simple Linear Regression	Predict dependent variable from 1 or more independent variables. Assumes a linear causal dependency of *y* on *x*.	Lung capacity does not vary with age.	`lm(y ~ x, data = data)` where y and x are continuous; a multiple regression may be specified as `lm(y ~ x + z, data = data)` where z is also continuous (integer or double)	Scatter plot with linear regression fit, with CI bands recommended. A grouped variable might be added as necessary (multiple regression).	Various data transformations can stabilise variances and correct for normality violations. Generalised Linear Models. Generalised Additive Models. Proportional odds ordinal logistic regression models for ordinal data.	Only data transformations covered in this module. Please ask me for information about GLMs, GAMs, and OLR if necessary.
Pearson's Product Moment Correlation	Test for covariation between two variables (continuous or ordinal). Paired samples are required, but the causal dependence of one on the other is not assumed.	There is no relationship between the lengths of left and right arms of individuals within a sample.	`cor.test(x, y)` where y and x are continuous	Scatter plot with regression linear regression line.	Spearman's *rho* or Kendal's *tau* correlation by ranks.	`cor.test(x, y, method = “spearman”)` `cor.test(x, y, method = “kendal”)` where x and y may both be ordinal

Nomenclature

Sample: A collection of random measurements taken as representative of the population; used interchangeably with 'measurement values', 'measurement variable', or 'variable'. It typically is the response or dependent variable.

One-sided: A hypothesis test asking if the statistic of one sample (typically the mean of the sample, as in *t*-tests) is a) larger than **or** b) smaller than that of the theoretical value or sample against which it is compared.

Two-sided: A hypothesis test asking if the statistic on one sample is different from that of the theoretical value or sample against which it is compared (i.e. making no distinction about whether it is larger or smaller).

Paired observations: Also called paired samples; samples are paired when the measurements taken are not independent, such as belonging to the same individual (e.g. left arm compared to right arm) or if the same individual is measured repeatedly (e.g. week 1 compared to week 2). In an ANOVA, non-independent samples are sometimes called 'repeated measures', specifically when a sample is measured at multiple times along a time series – although 'repeated measures' ANOVAs can be used, nowadays we use mixed effects models to accommodate this kind of experimental design. We will not cover mixed effects models in this module, but you can ask me about them if you are interested.

Factor variable: Typically a variable that contains the levels that define the experimental treatment, and according to which the measurements of the response variable are grouped. There might be multiple factor variables, e.g. as in a two-way ANOVA. Typically factor variables are independent variables.

****Continuous covariate:*** This is a variable with continuous data (such as age, length, etc.) that is used as an independent variable within an ANCOVA alongside a factor variable. When a continuous covariate is present together with a factor variable with multiple levels, each of these levels has an associated regression line (e.g. in the Lung Capacity data where we can fit a separate regression line for males and females). In this case we may want to compare the regression lines and ask if they are different from each other in either slope or intercept. The implication for H_0 is that we may restate our hypotheses with regards to slopes and intercepts. As such, an ANCOVA is simply a Simple Linear Regression that also includes a factor variable.

§*Visualisations:* Use plots of the median for non-parametric data.