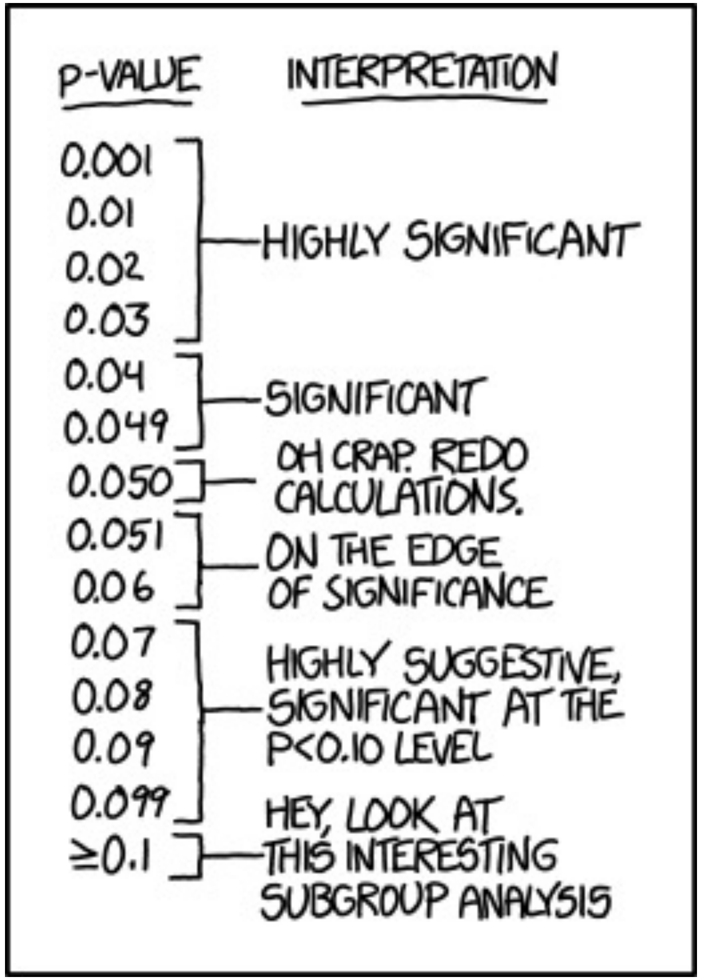
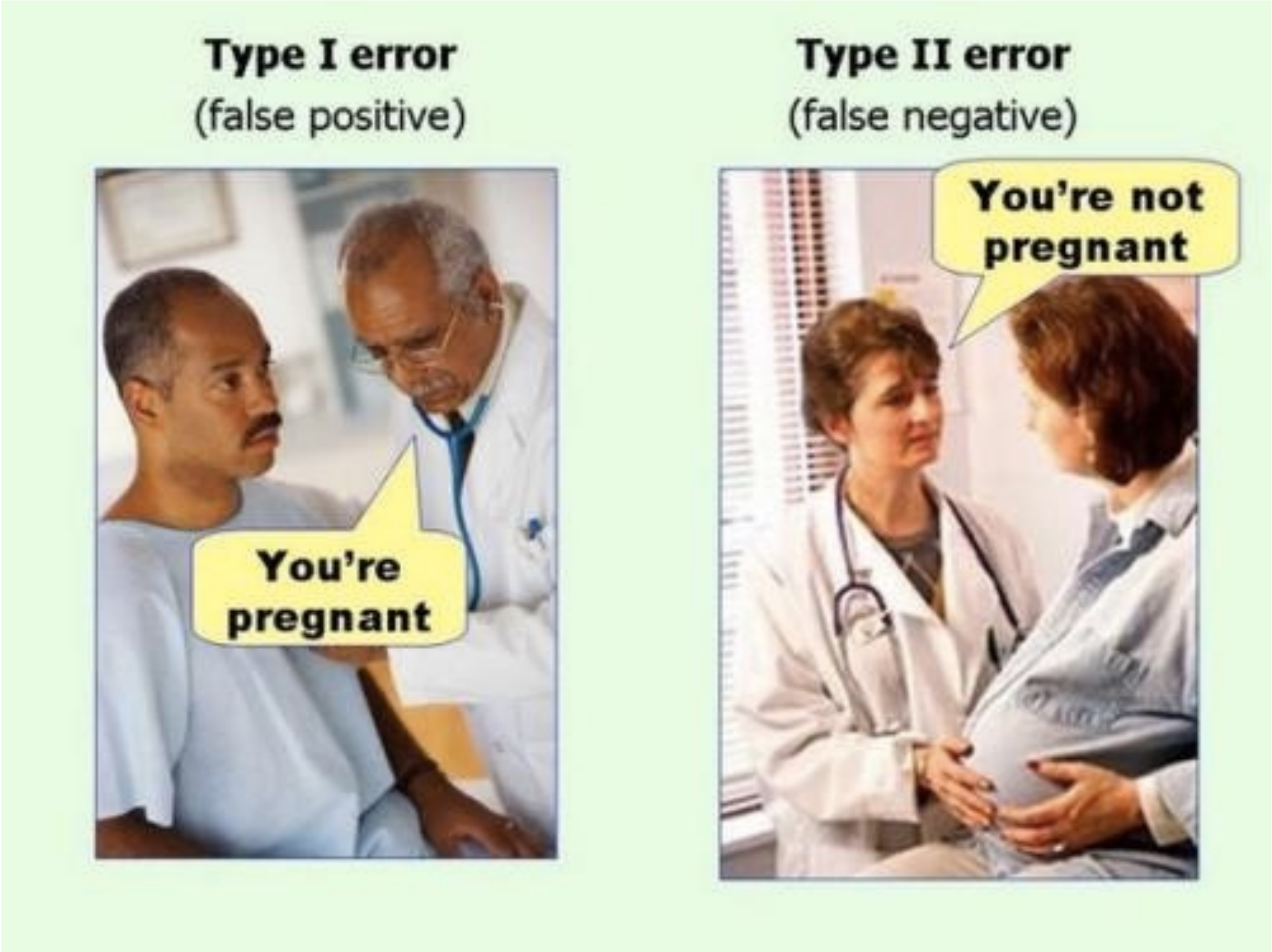

P-VALUE
INTERPRETATION
0.001
0.01
0.02
0.03
HIGHLY SIGNIFICANT
0.04
0.049
SIGNIFICANT
0.050
OH CRAP. REDO CALCULATIONS.
0.051
0.06
ON THE EDGE OF SIGNIFICANCE
0.07
0.08
0.09
0.099
HIGHLY SUGGESTIVE, SIGNIFICANT AT THE P<0.10 LEVEL
≥0.1
HEY, LOOK AT THIS INTERESTING SUBGROUP ANALYSIS


Type I error
(false positive)
You're pregnant
Type II error
(false negative)
You're not pregnant

Types of Data

Numerical

- Quantitative
- Types:
  - Continuous (measurable), can take any value between 2 specified values
    - Fish length
  - Discrete (counts), only certain values are possible
    - Number of fin strokes

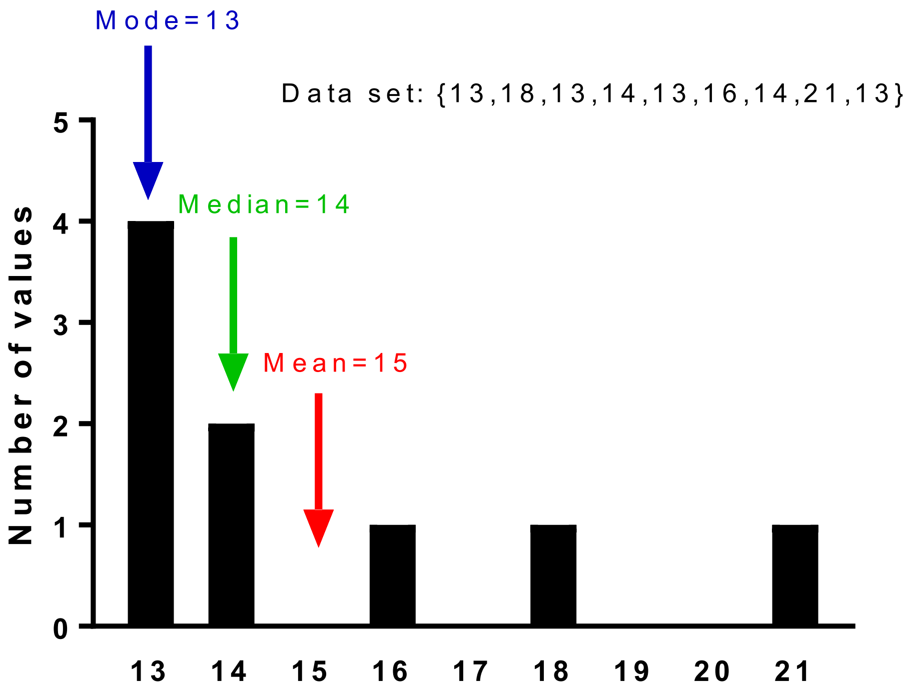
Categorical

- Distinct groups, often qualitative
- Differences between values are unknown
- Types:
  - Nominal (without order)
    - Transgenic mice (WT, Het, KO)
  - Dichotomous (2 categories without order)
    - Aquatic/terrestrial, male/female
  - Ordinal (with order)
    - 4-point pain scale (none, light, moderate, severe)

Descriptive Statistics

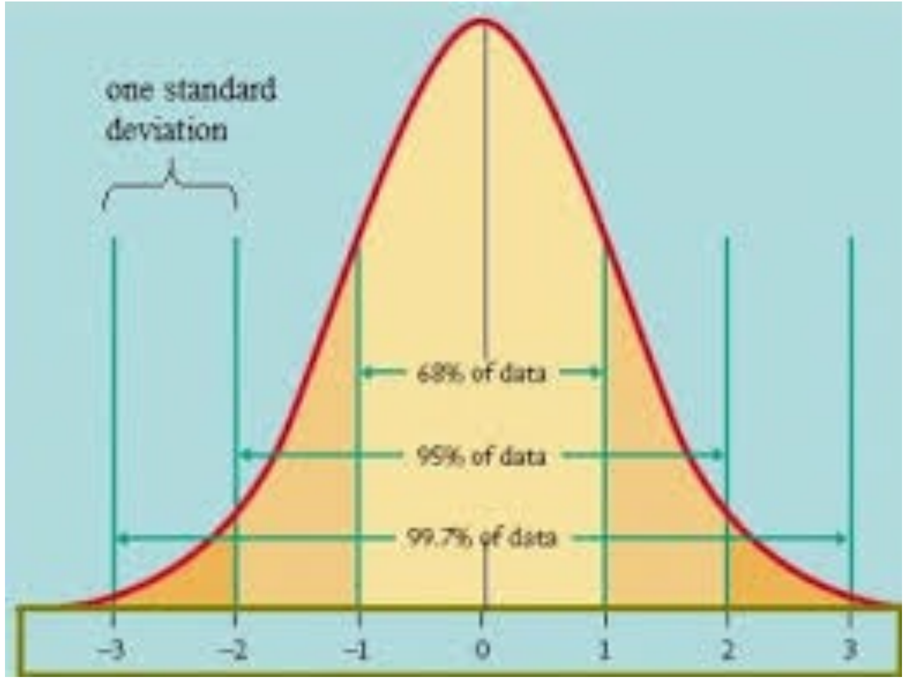
Central Tendency

- Mean, median, mode



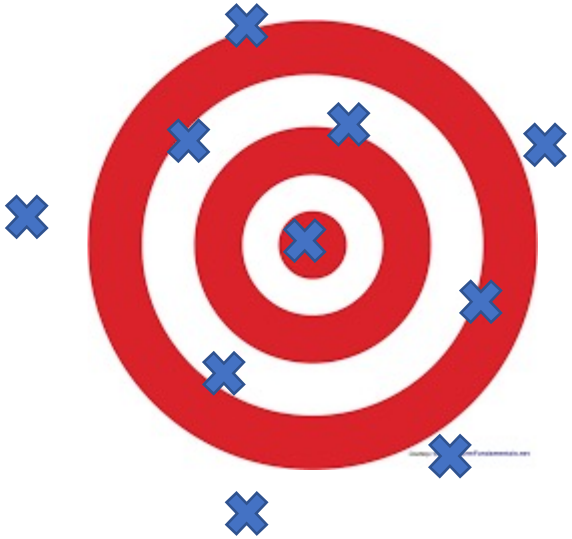
Data Spread

- Standard deviation; SD = $\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}$

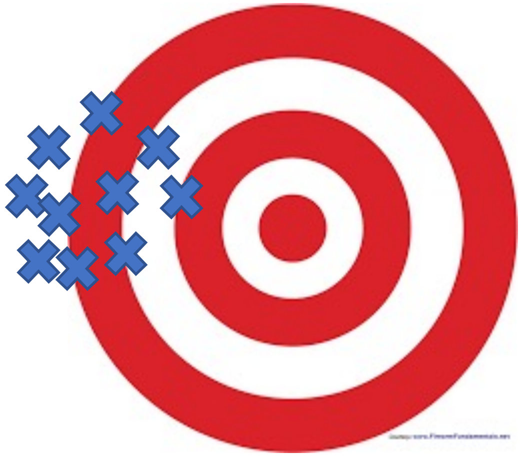


Confidence Interval - a measure of precision

Precision vs. Accuracy



Accurate but not precise



Precise but not accurate

Precise and accurate

Confidence Interval (CI) of the Mean

A CI provides a range of values which is likely to contain the population mean

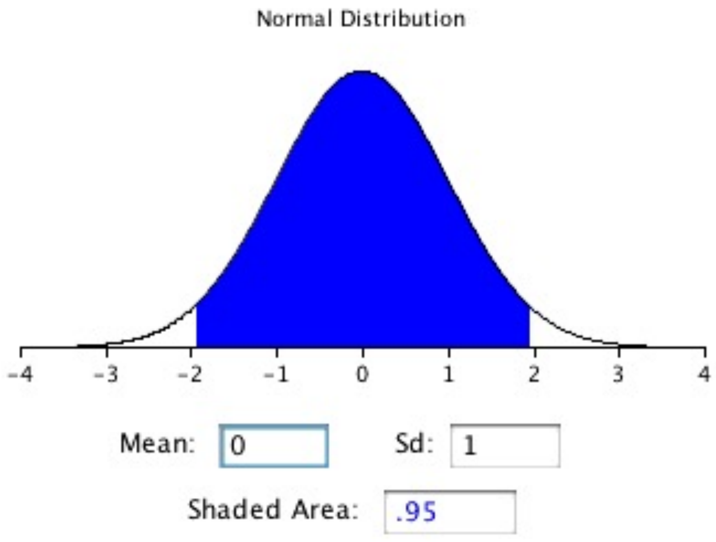
95% CIs:

Repeat your experiment 100x

- 95 of your results will fall within the CI

Wide CI = low precision

Narrow CI = high precision



$$\textit{For a normal distribution}$$

$$95\%\ CI = Mean \pm \left(1.96 \times \frac{SD}{\sqrt{n}}\right)$$

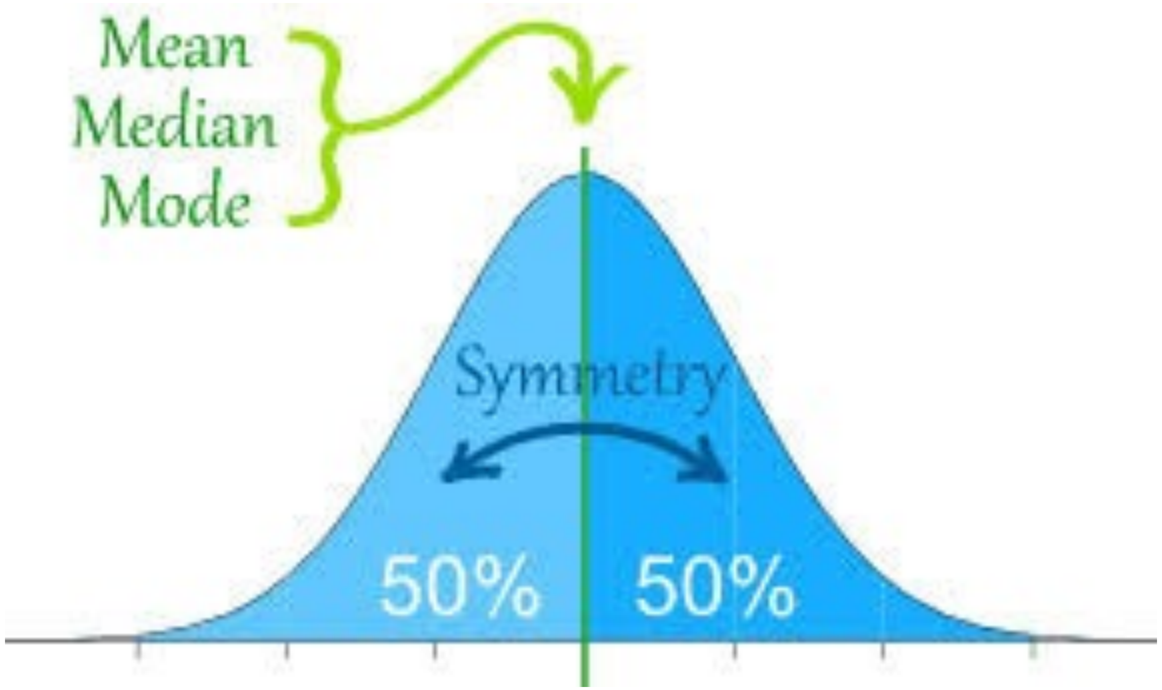
Probability Distributions

Continuous data

<u>Normal distribution </u>(Gaussian)

Based on *Central Limit Theorem*:

Typically used for large sample sizes (n>30) with a known population standard deviation (SD)



Probability Distributions

Continuous data

Normal distribution (Gaussian)

Based on *Central Limit Theorem*:

Typically used for large sample sizes (n>30) with a known population standard deviation (SD)

Other Distributions

- Student's t
  - Continuous data, small sample
- Poisson
  - Rare discrete data (mutations)
- Binomial
  - 2-outcome discrete data (yes/no)
- Chi squared
  - Dichotomous categorical data

Type I and II error

Null Hypothesis, H_o – there is no real difference between groups

Type I error (α)

False positive rate

We reject the H_o

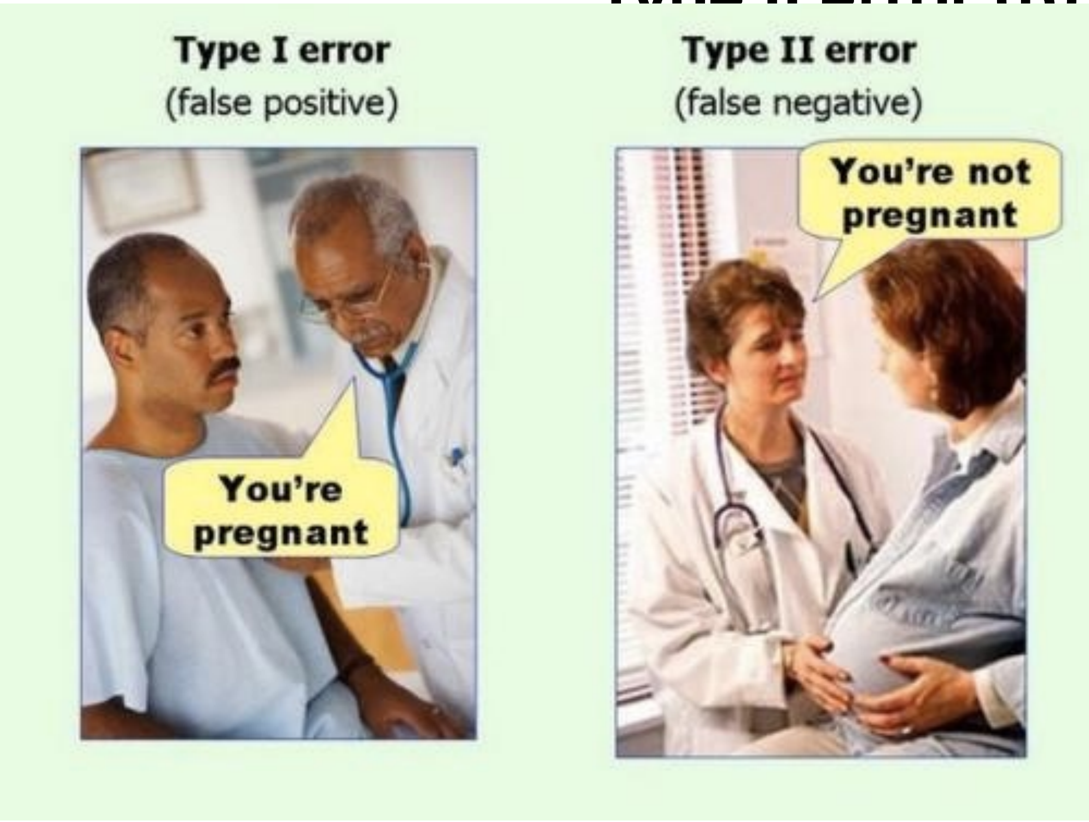
We say there is a
there is none

Type II error (β)

ate

$_o$ when it is false

o difference
real difference



There are many kinds of statistical tests

- T-test
- Analysis of variance (ANOVA)
- Analysis of covariance (ANCOVA)
- Regression
- Correlation
- Chi-square
- Logistic regression
- Multiple linear regression
- Repeated measures ANOVA

There are many kinds of statistical tests

- T-test
- Analysis of variance (ANOVA)
- Analysis of covariance (ANCOVA)
- Regression
- Correlation
- Chi-square
- Logistic regression
- Multiple linear regression
- Repeated measures ANOVA

But how do we know which test we should do??

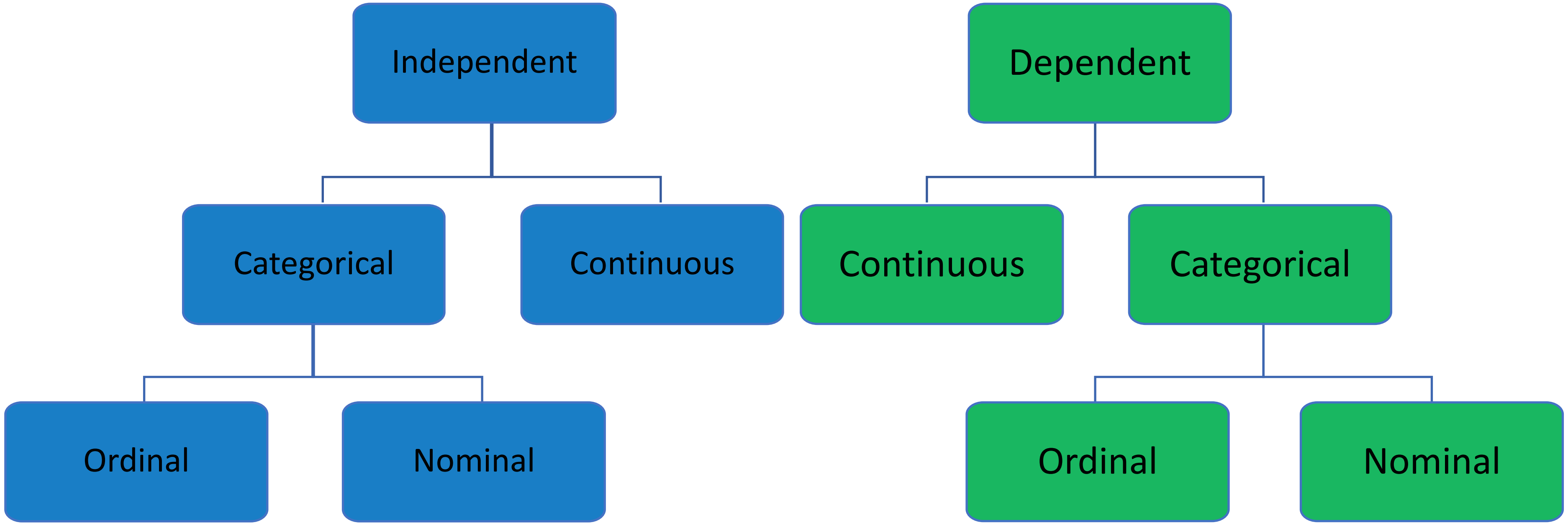
What type of data do I have?

- Independent *vs* dependent variables:
  - Independent = question (what you’re changing)
  - Dependent = answer (what you’re measuring)
- General experimental question:
  - Does changing the independent variable correlate with changes in the dependent variable?

What type of data do I have?

- Continuous *vs* categorical data

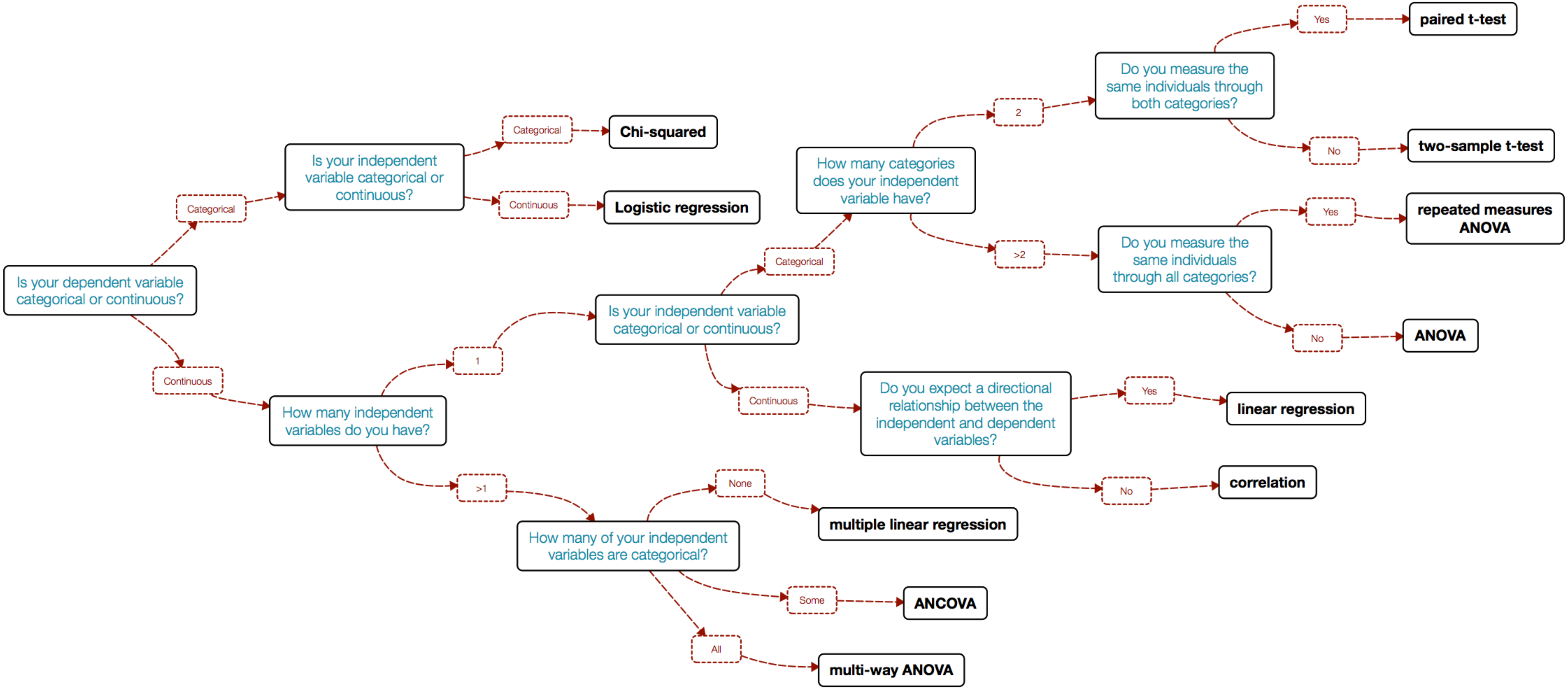
What type of data do I have?



There are many kinds of statistical tests

INDEPENDENT \ DEPENDENT	Categorical	Continuous
Categorical	• Chi-squared	• T-test • ANOVA • Repeated measures ANOVA • ANCOVA
Continuous	• Logistic regression	• Regression • Correlation • ANCOVA • Multiple linear regression

How do I choose which test to run?



P-value

Calculated probability, *p*

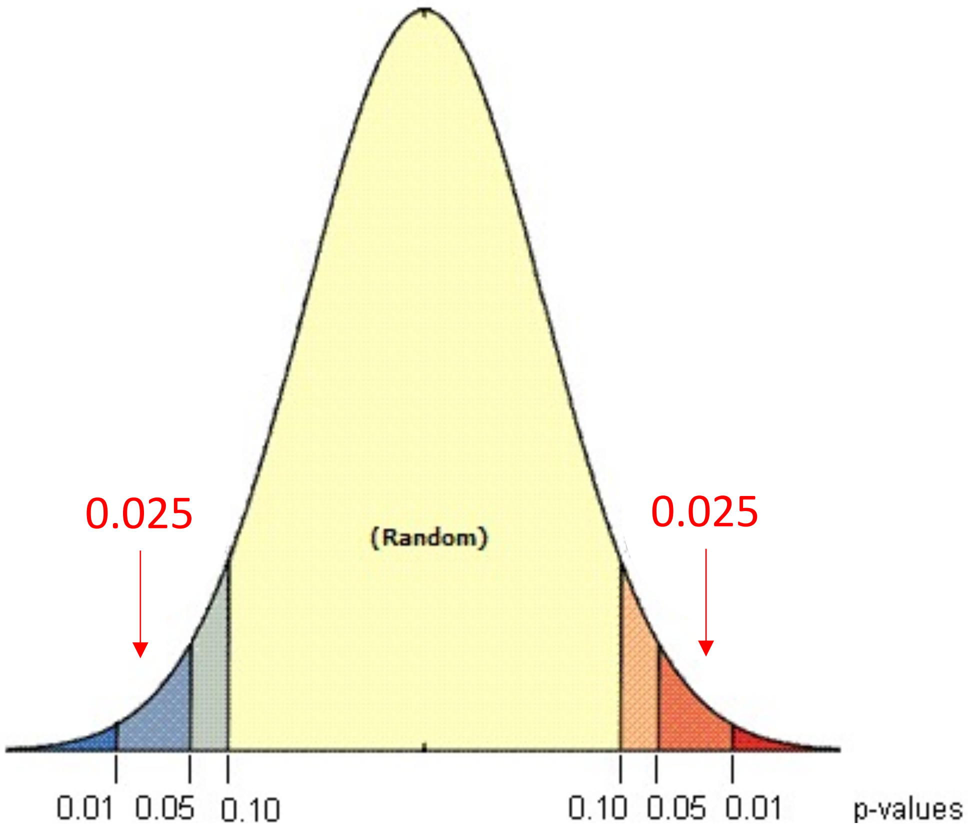
The probability of an observed value when H_o is true

- A true H_o means there is no true difference between groups

When do we reject H_o?

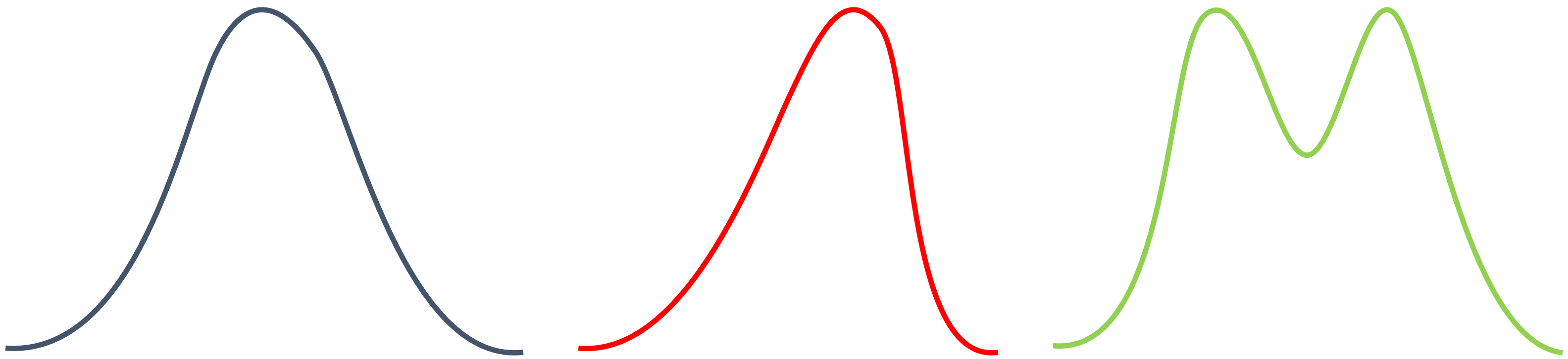
We set a significance level, p=0.05

Beyond p=0.05, the values are considered extreme and we reject H_o



Assumptions of statistical tests

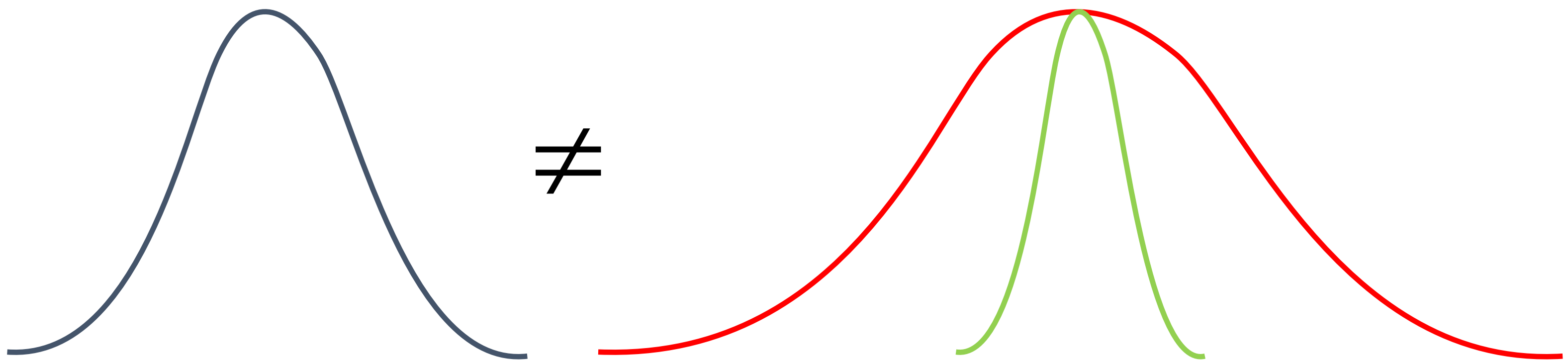
- Normal distribution



Test for normality with Shapiro-Wilk test

Assumptions of statistical tests

- Normal distribution
- Equal variance between groups



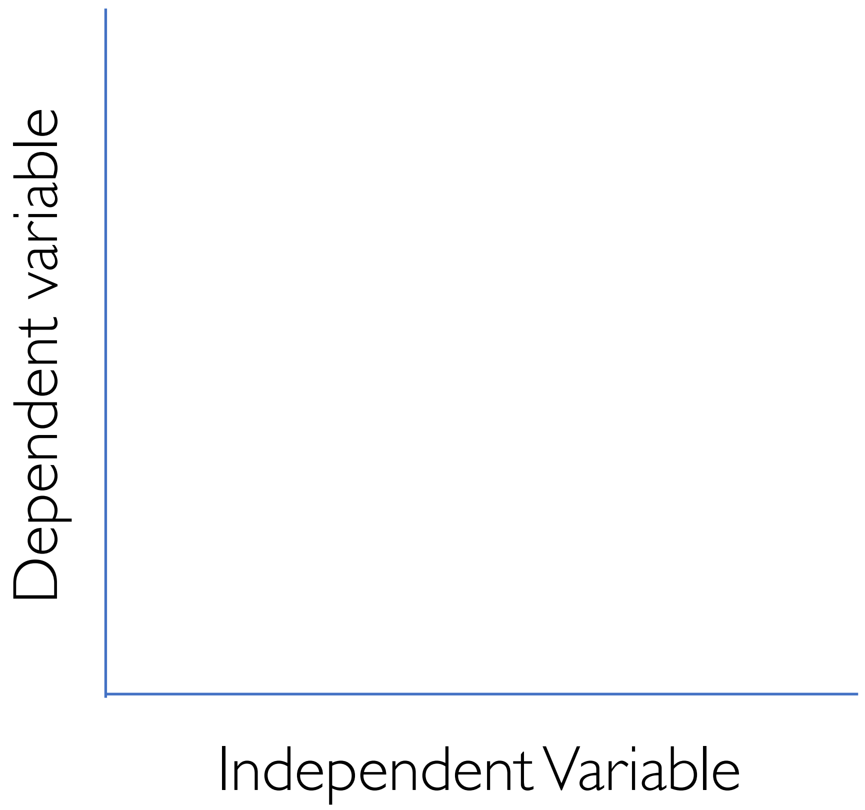
Test for homogeneity of variance with Levene's test

Assumptions of statistical tests

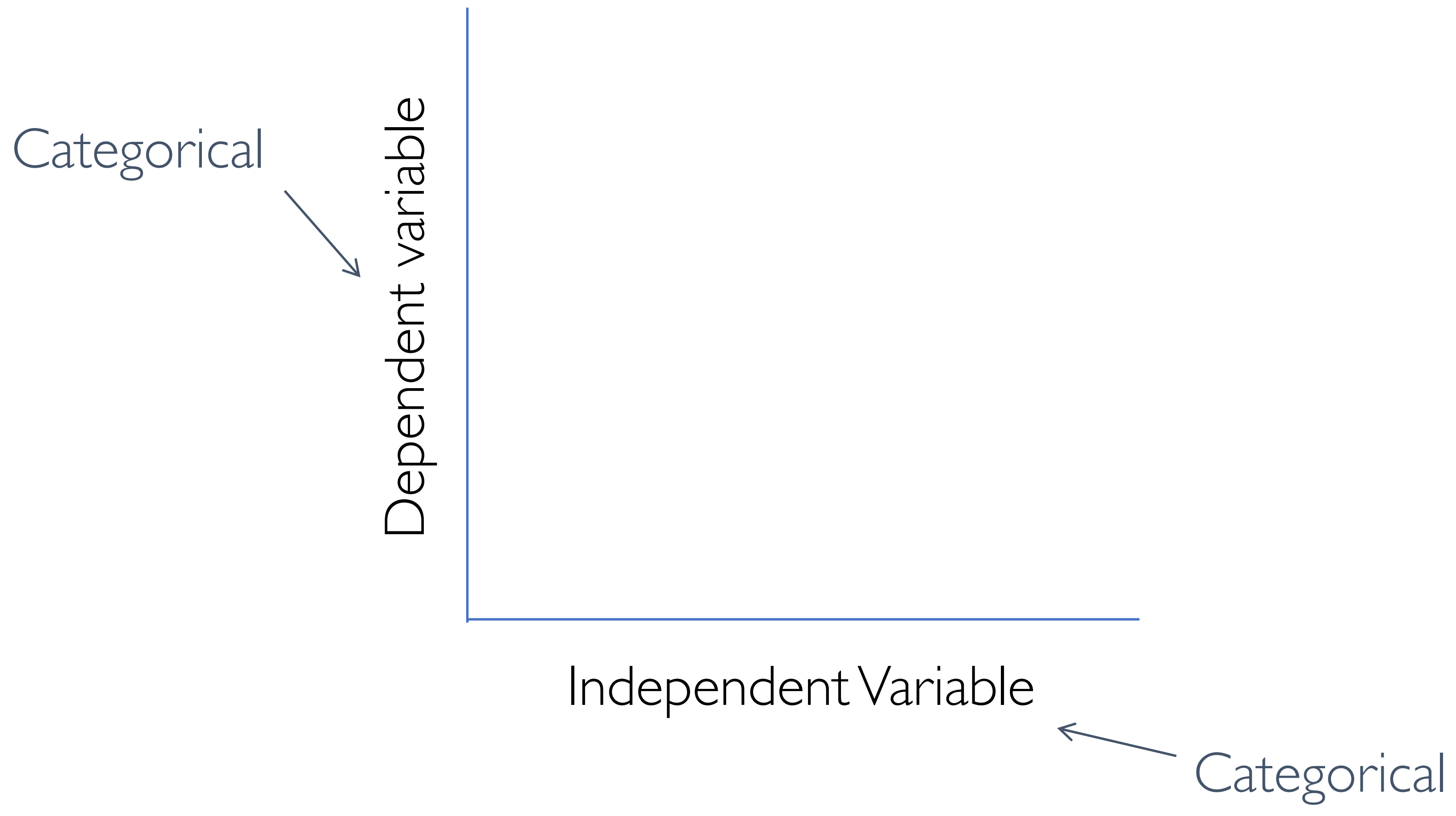
- Normal distribution
- Equal variance between groups

- Does your data meet these assumptions?
  - YES → Parametric tests
  - NO → Non-parametric tests

Graphing fundamentals

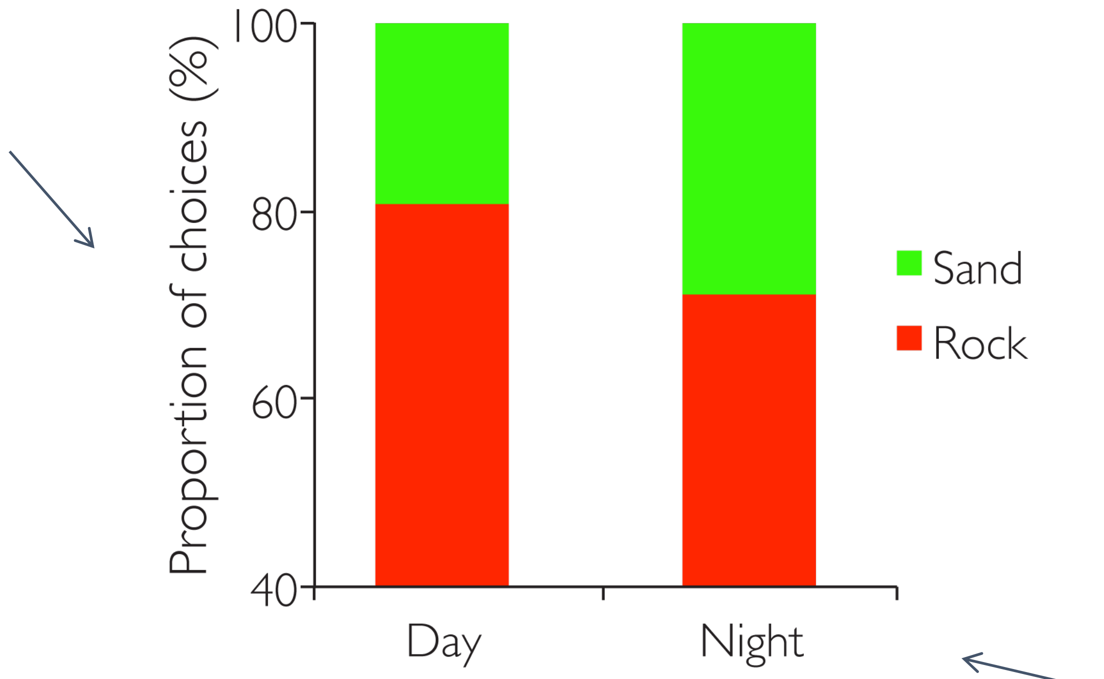


Graphing fundamentals



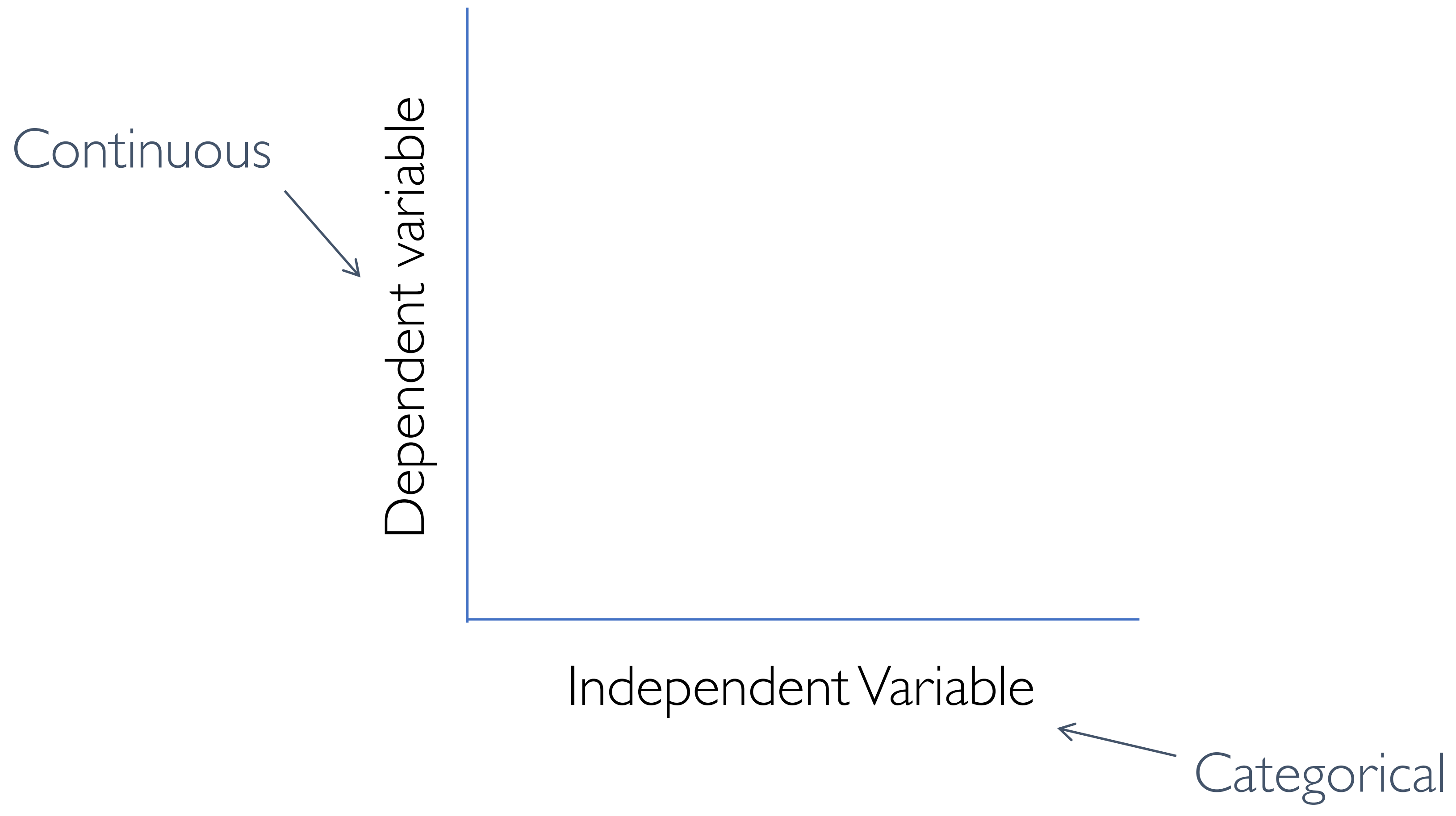
Do lizards prefer to run on rock or sand? And does it matter whether it's day or night?

Categorical



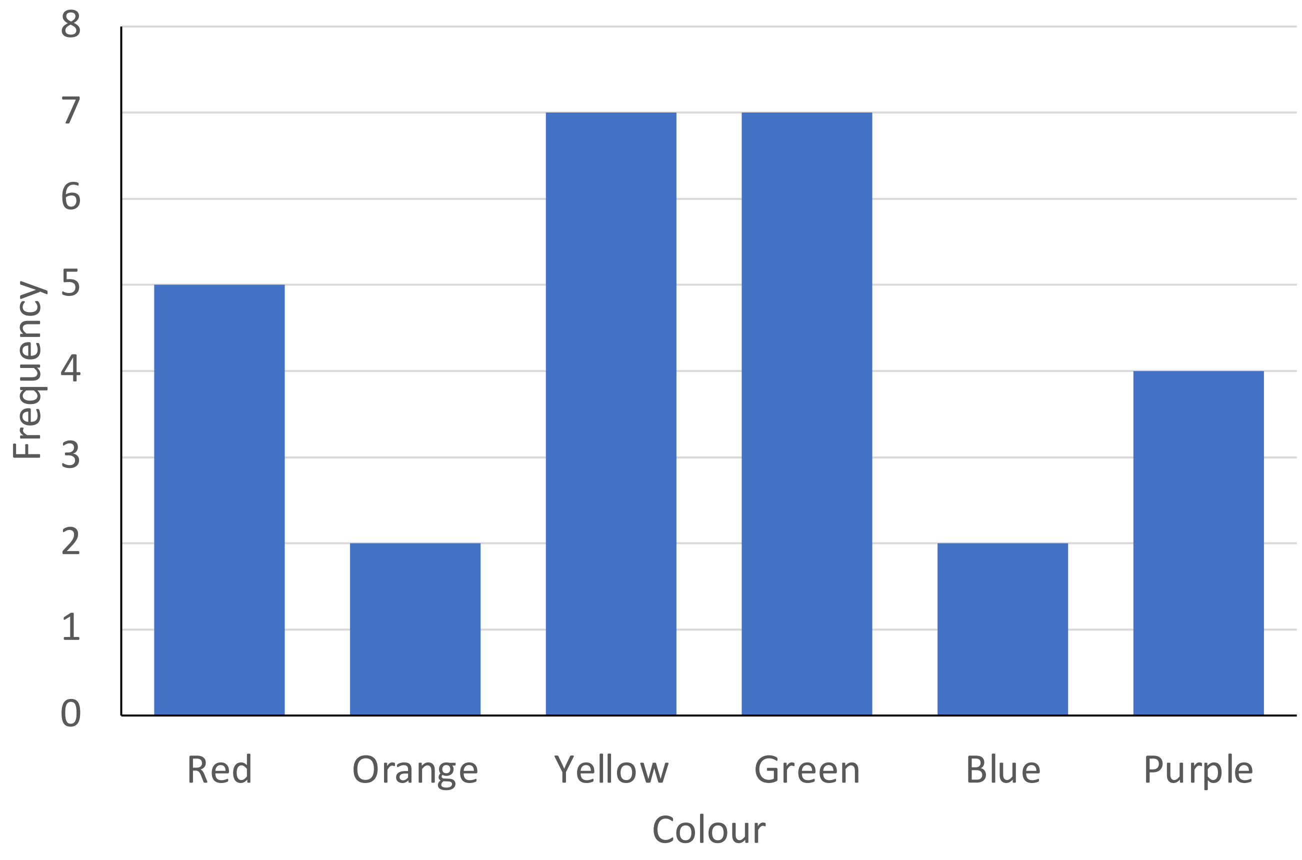
Categorical

Graphing fundamentals



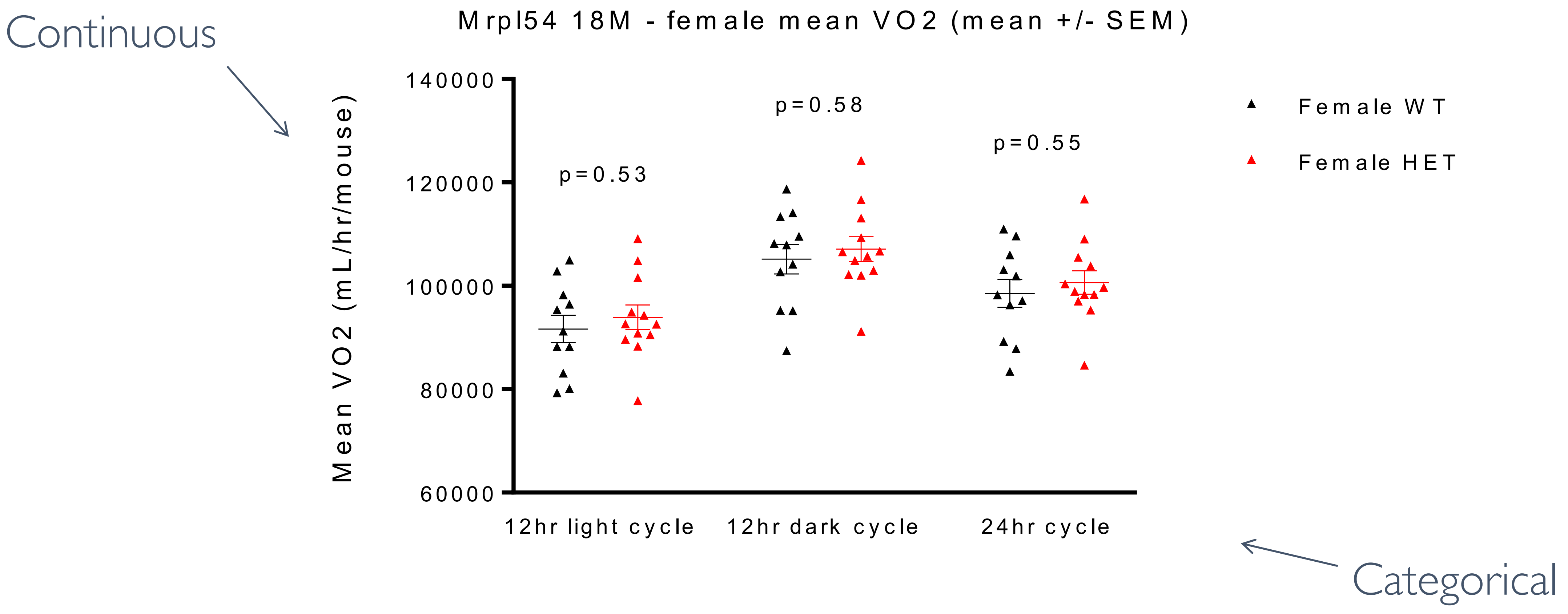
How many of each colour are in a box of Smarties?

Continuous

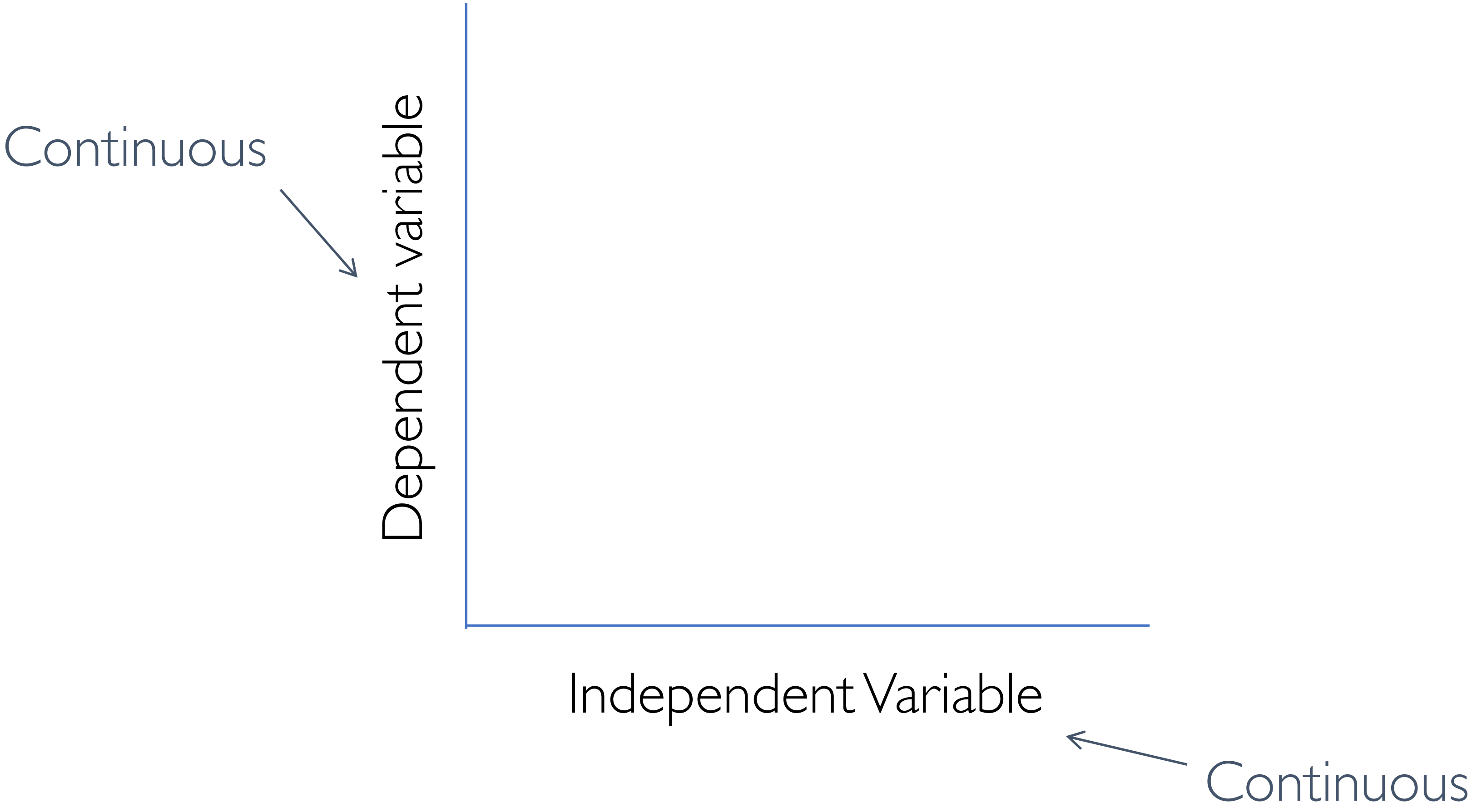


Categorical

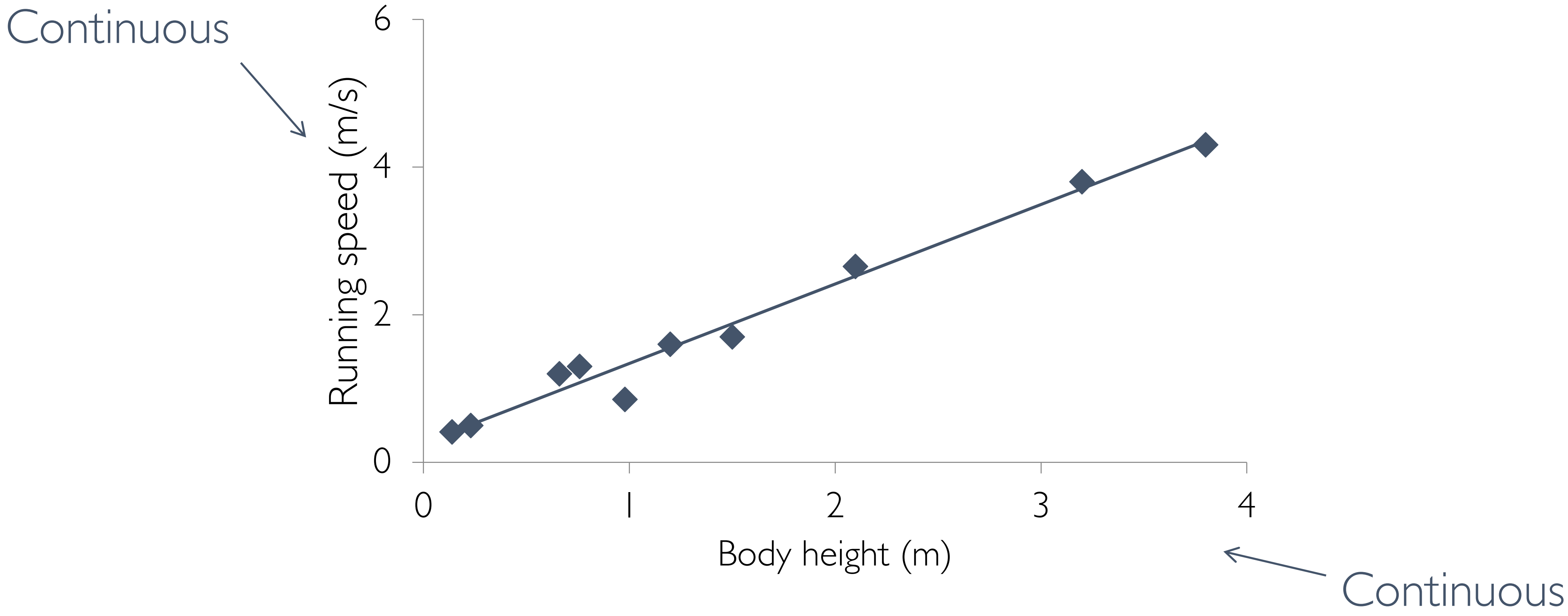
Is oxygen consumption different between wildtype and mutant mice?
And does that depend on the light cycle?



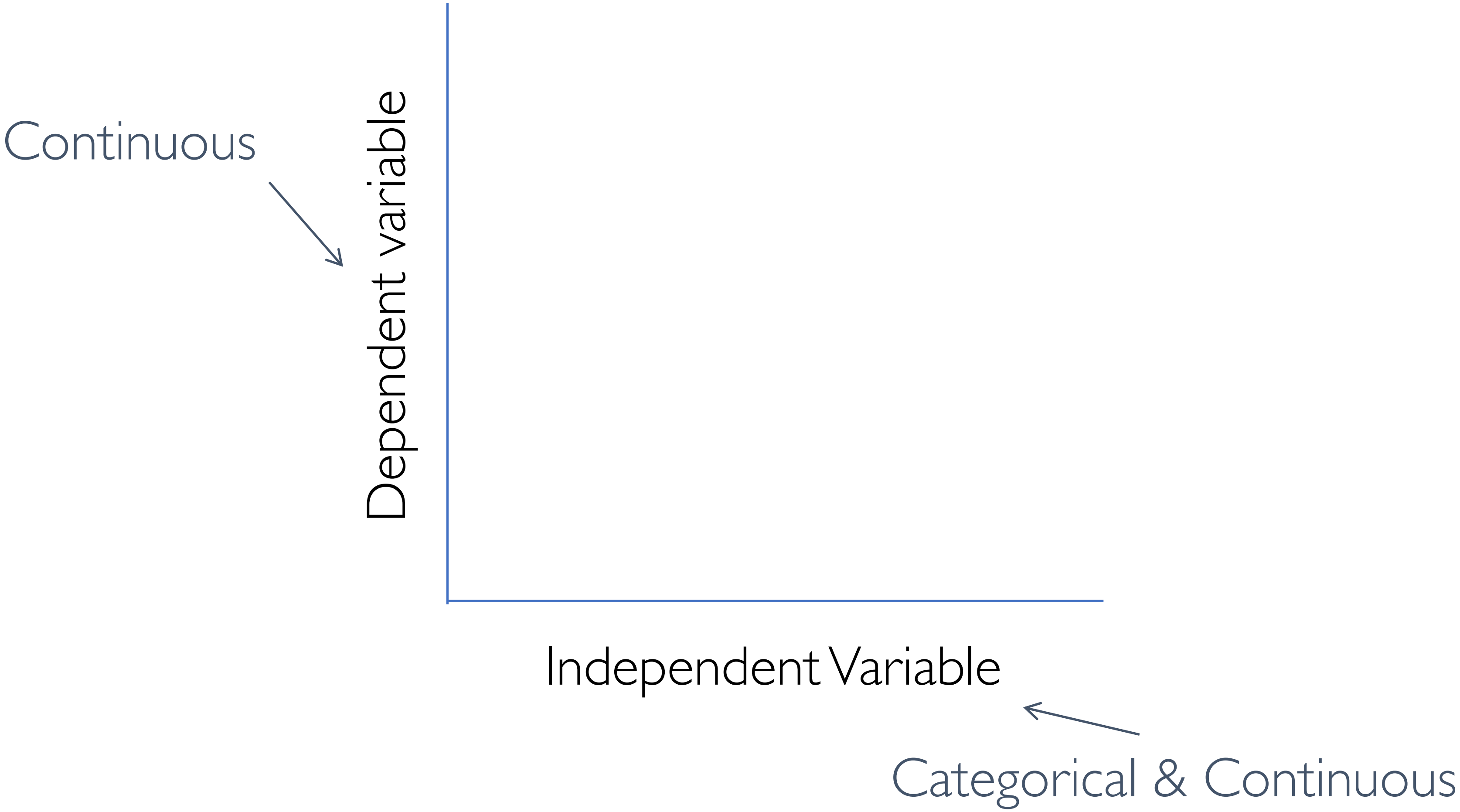
Graphing fundamentals



Can taller people run faster than shorter people?

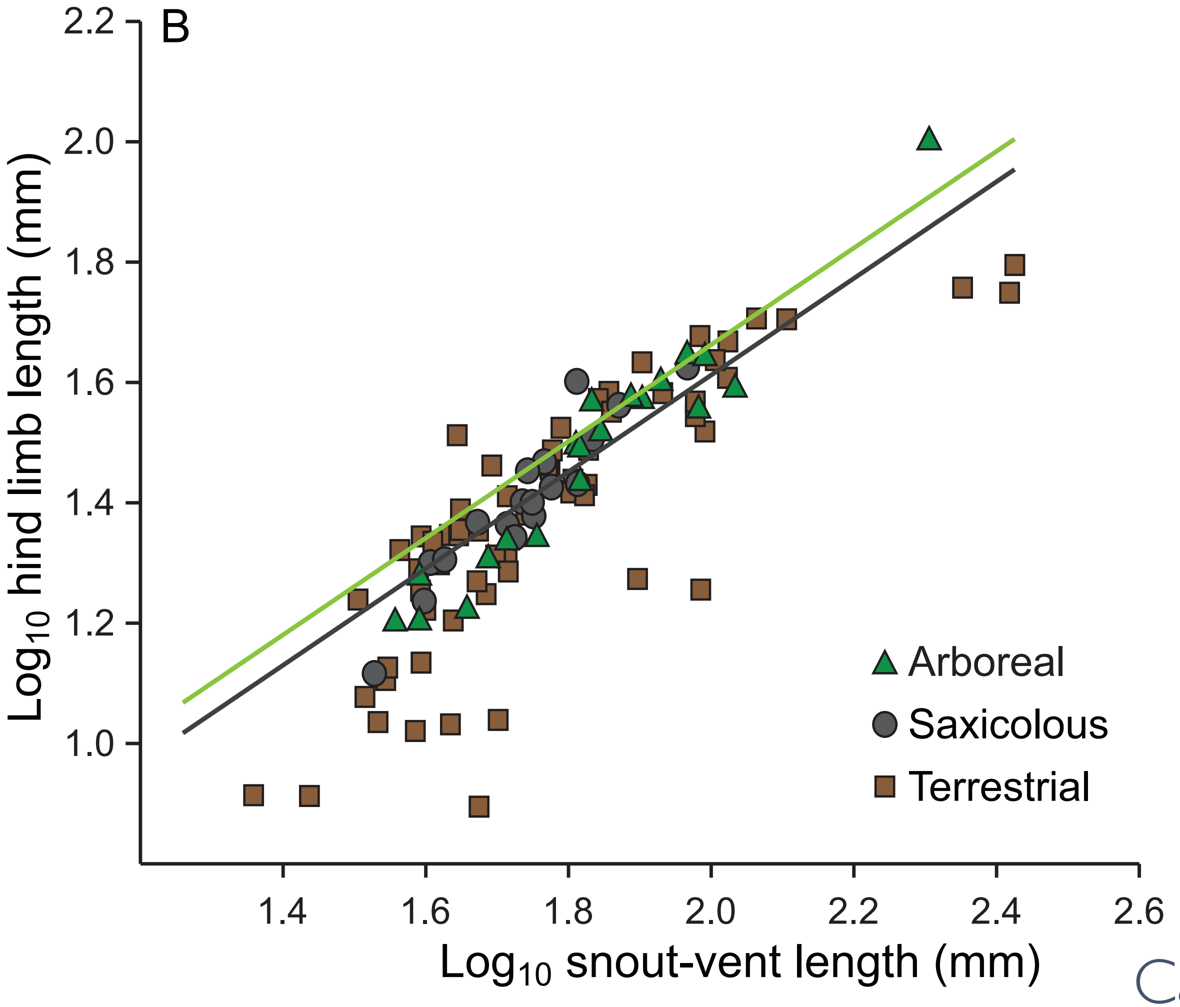


Graphing fundamentals



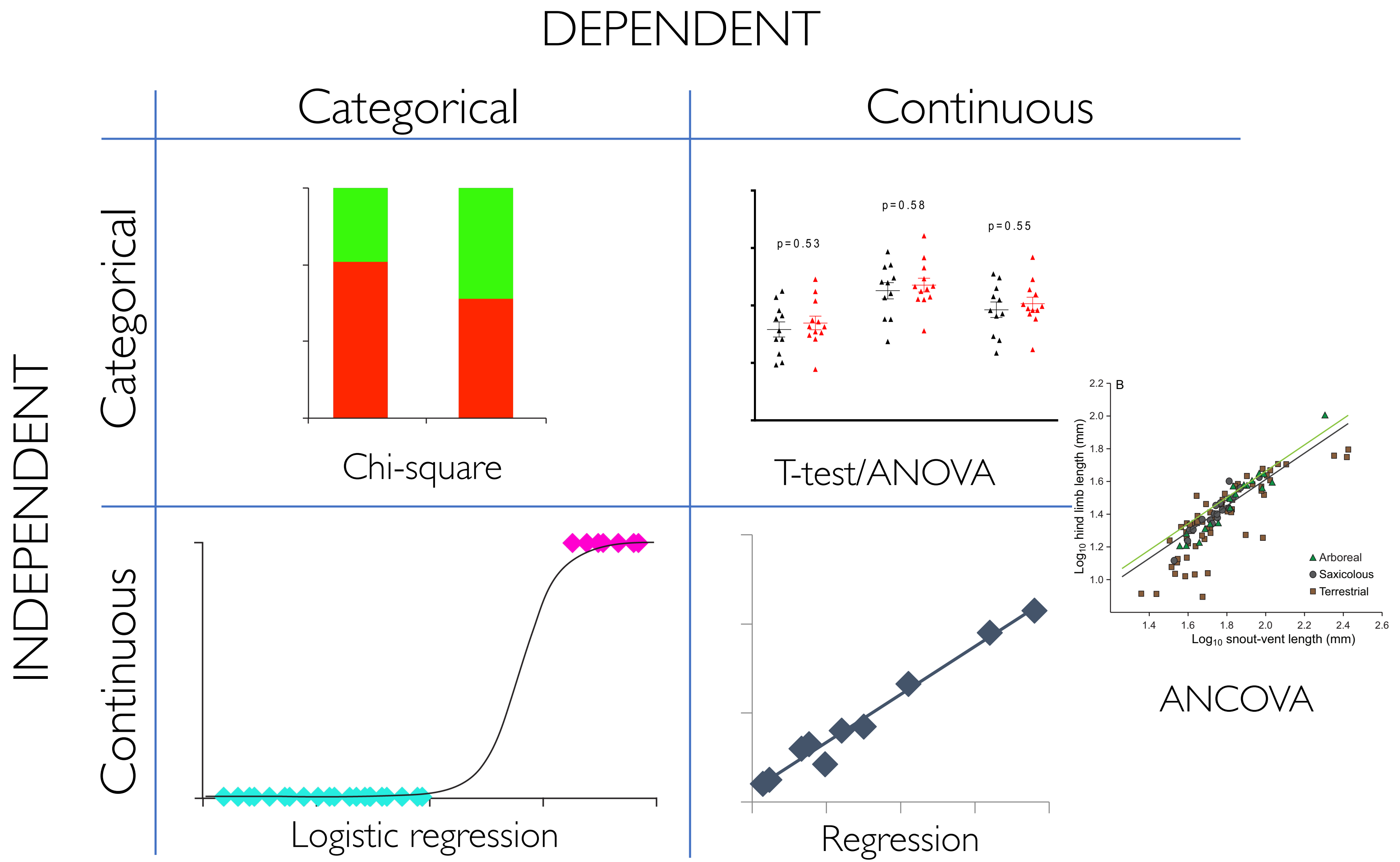
Are hind limbs longer in climbing skinks than in terrestrial skinks?

Continuous



Categorical & Continuous

Graphs + Stats Summary



Statistical vs. Biological Significance

p<0.05 – yay!

But is the effect size meaningful?

<u>Example:</u>

Population: people with chronic pain

Comparison: control vs. treated

Mean difference is 0.25 of a point on a 10-pt Likert Scale

- 1=no pain; 10=excruciating pain

Mean difference result gives *p*<0.05

But a 0.25 point difference has no clinical relevance

Confidence Intervals can also help!

- Recall that CIs measure precision

Let's say the result is statistically *and* clinically relevant (*p*<0.05; mean difference is 2 pts)

But the 95% CI is wide:

Do the CI limits support a meaningful result?