Analysis of Quantitative data
Introduction

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v2020-08

Outline of this section

- Assumptions for parametric data
- Comparing two means: **Student's *t*-test**
- Comparing more than 2 means
    - One factor: **One-way ANOVA**
    - Two factors: **Two-way ANOVA**
- Relationship between 2 continuous variables:
    - Linear: **Correlation**
    - Non-linear: **Curve fitting**
    - **Model diagnostics: Goodness-of-fit**
- **Non-parametric tests**

Introduction

- **Key concepts to always keep in mind**
  - Null hypothesis and error types
  - Statistics inference
  - Signal-to-noise ratio

The null hypothesis and the error types

- The null hypothesis (H_0): H_0 = no effect
    - e.g. no difference between 2 genotypes
- The aim of a statistical test is to reject or not H_0.

Statistical decision	True state of H_0	
	H_0 True (no effect)	**H_0 False (effect)**
Reject H_0	**Type I error α** **False Positive**	Correct **True Positive**
Do not reject H_0	Correct **True Negative**	**Type II error β** **False Negative**

- Traditionally, a test or a difference is said to be "**significant**" if the probability of type I error is: **α =< 0.05**
- **High specificity** = low **False Positives** = low **Type I error**
- **High sensitivity** = low **False Negatives** = low **Type II error**

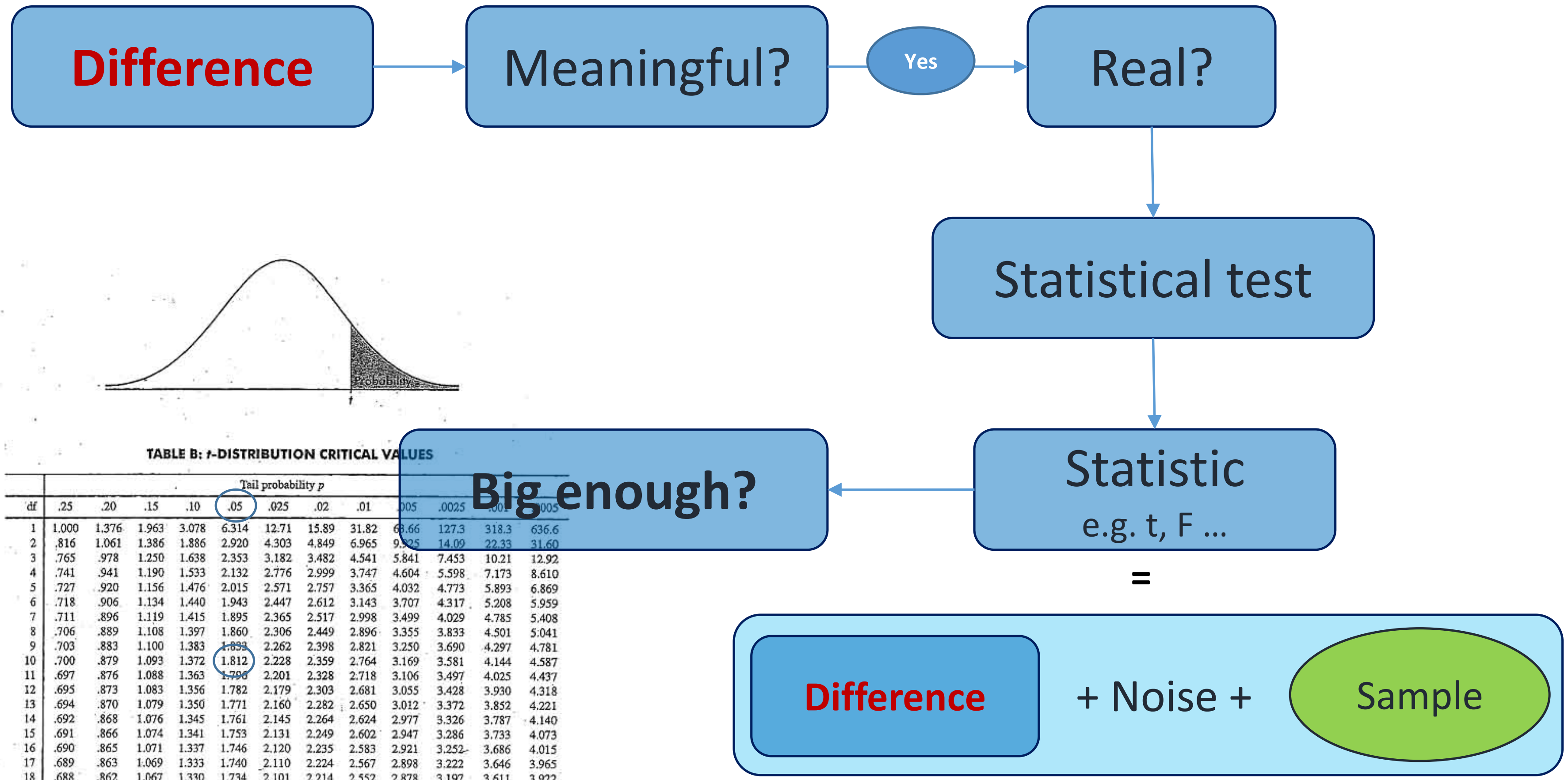
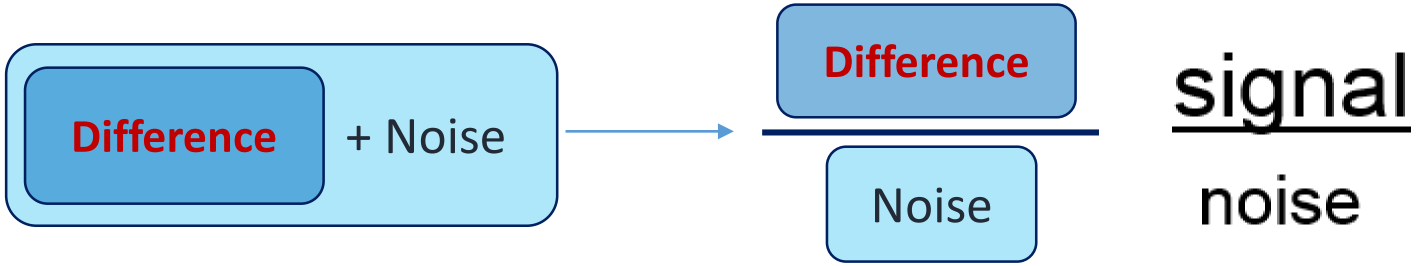


TABLE B: t-DISTRIBUTION CRITICAL VALUES

	Tail probability p											
df	.25	.20	.15	.10	.05	.025	.02	.01	.005	.0025	.001	.0005
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.82	63.66	127.3	318.3	636.6
2	.816	1.061	1.386	1.886	2.920	4.303	4.849	6.965	9.925	14.09	22.33	31.60
3	.765	.978	1.250	1.638	2.353	3.182	3.482	4.541	5.841	7.453	10.21	12.92
4	.741	.941	1.190	1.533	2.132	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	.727	.920	1.156	1.476	2.015	2.571	2.757	3.365	4.032	4.773	5.893	6.869
6	.718	.906	1.134	1.440	1.943	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	.711	.896	1.119	1.415	1.895	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	.706	.889	1.108	1.397	1.860	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	.703	.883	1.100	1.383	1.833	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	.700	.879	1.093	1.372	1.812	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	.697	.876	1.088	1.363	1.796	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	.695	.873	1.083	1.356	1.782	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	.694	.870	1.079	1.350	1.771	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	.692	.868	1.076	1.345	1.761	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	.691	.866	1.074	1.341	1.753	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	.690	.865	1.071	1.337	1.746	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	.689	.863	1.069	1.333	1.740	2.110	2.224	2.567	2.898	3.222	3.646	3.965
18	.688	.862	1.067	1.330	1.734	2.101	2.214	2.552	2.878	3.197	3.611	3.922
19	.688	.861	1.066	1.328	1.729	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	.687	.860	1.064	1.325	1.725	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	.686	.859	1.063	1.323	1.721	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	.686	.858	1.061	1.321	1.717	2.074	2.183	2.508	2.819	3.119	3.505	3.792

Signal-to-noise ratio

- Stats are all about understanding and controlling variation.



signal / noise — If the **noise is low** then the **signal is detectable** …
= statistical significance

signal / noise — … but if the **noise** (i.e. interindividual variation) **is large** then the **same signal will not be detected**
= no statistical significance

- In a statistical test, the ratio of signal to noise determines the significance.

Analysis of Quantitative Data

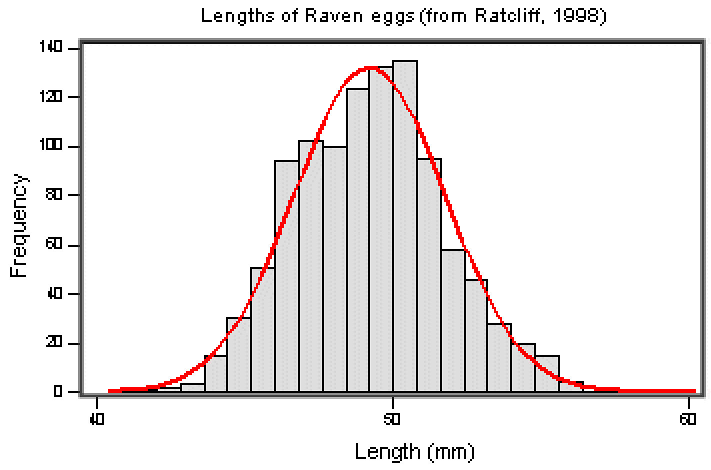
- Choose the correct statistical test to answer your question:
  - They are 2 types of statistical tests:
    - **Parametric tests** with 4 assumptions to be met by the data,
    - **Non-parametric tests** with no or few assumptions (e.g. Mann-Whitney test) and/or for qualitative data (e.g. Fisher's exact and χ^2 tests).

Assumptions of Parametric Data

- All parametric tests have 4 basic assumptions that must be met for the test to be accurate.

First assumption: Normally distributed data

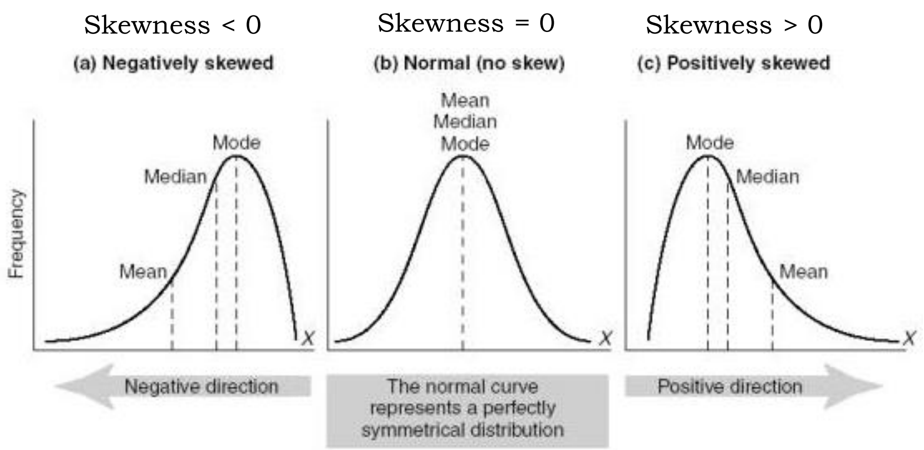
- Normal shape, bell shape, Gaussian shape

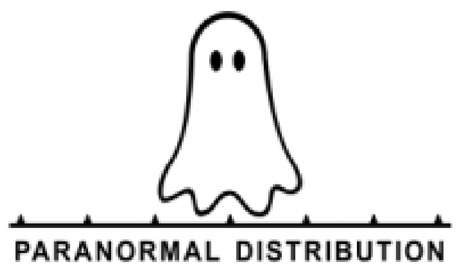


- Transformations can be made to make data suitable for parametric analysis.

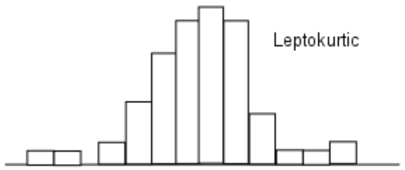
Assumptions of Parametric Data

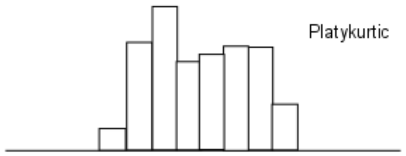
- Frequent departures from normality:
  - Skewness: lack of symmetry of a distribution

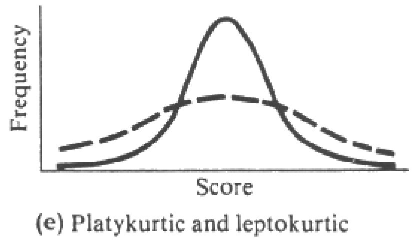




  - Kurtosis: measure of the degree of 'peakedness' in the distribution
    - The two distributions below have the same variance approximately the same skew, but differ markedly in kurtosis.







More peaked distribution: kurtosis > 0

Flatter distribution: kurtosis < 0

Assumptions of Parametric Data

Second assumption: Homoscedasticity (Homogeneity in variance)

- The variance should not change systematically throughout the data

Third assumption: Interval data (linearity)

- The distance between points of the scale should be equal at all parts along the scale.

Fourth assumption: Independence

- Data from different subjects are independent
  - Values corresponding to one subject do not influence the values corresponding to another subject.
  - Important in repeated measures experiments

Analysis of Quantitative Data

- **Is there a difference between my groups regarding the variable I am measuring?**
  - e.g. are the mice in the group A heavier than those in group B?
    - Tests with 2 groups:
      - Parametric: **Student's *t*-test**
      - Non parametric: **Mann-Whitney/Wilcoxon rank sum test**
    - Tests with more than 2 groups:
      - Parametric: **Analysis of variance (one-way and two-way ANOVA)**
      - Non parametric: **Kruskal Wallis (one-way ANOVA equivalent)**
- **Is there a relationship between my 2 (continuous) variables?**
  - e.g. is there a relationship between the daily intake in calories and an increase in body weight?
    - Test: **Correlation (parametric or non-parametric) and Curve fitting**