Performing and reporting t-tests on experimental data

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Biol2010

Introduction

- This self guided tutorial will should provide you with all the background and procedural information required to:
  1) Build experimental hypotheses
  2) Statistical Hypothesis testing
  3) Selection of statistical test to analyze data by comparing means
  4) Perform t-tests using SPSS software
  5) Properly interpret and report your results
  6) Graphing your results
- SPSS statistical software is available in York computer labs and accessible from home using York's remote File Access System (FAS)
  – ***WARNING*** The FAS may involve a lengthy installation process and I have found it to be finicky, sometimes requiring multiple attempts for successful installation. Be aware of this if you are downloading the software at home… at midnight… the evening before your report is due.

1) Hypothesis Building

- Creating testable hypothesis is central to scientific method
  - **Null (H_o) hypothesis** – 'no effect' or 'no difference' between samples or treatments
  - **Alternative (H_a) hypothesis** – experimental treatment has a certain statistically significant
  - A claim for which we are trying to find evidence

Example

H_o: "Different colours of light display no differences in oxygen evolution"

(H_o: $x_2=x_1$ <u>or</u> $x_2-x_1=0$)

H_a: "White light stimulates photosynthesis to evolve more oxygen than blue"

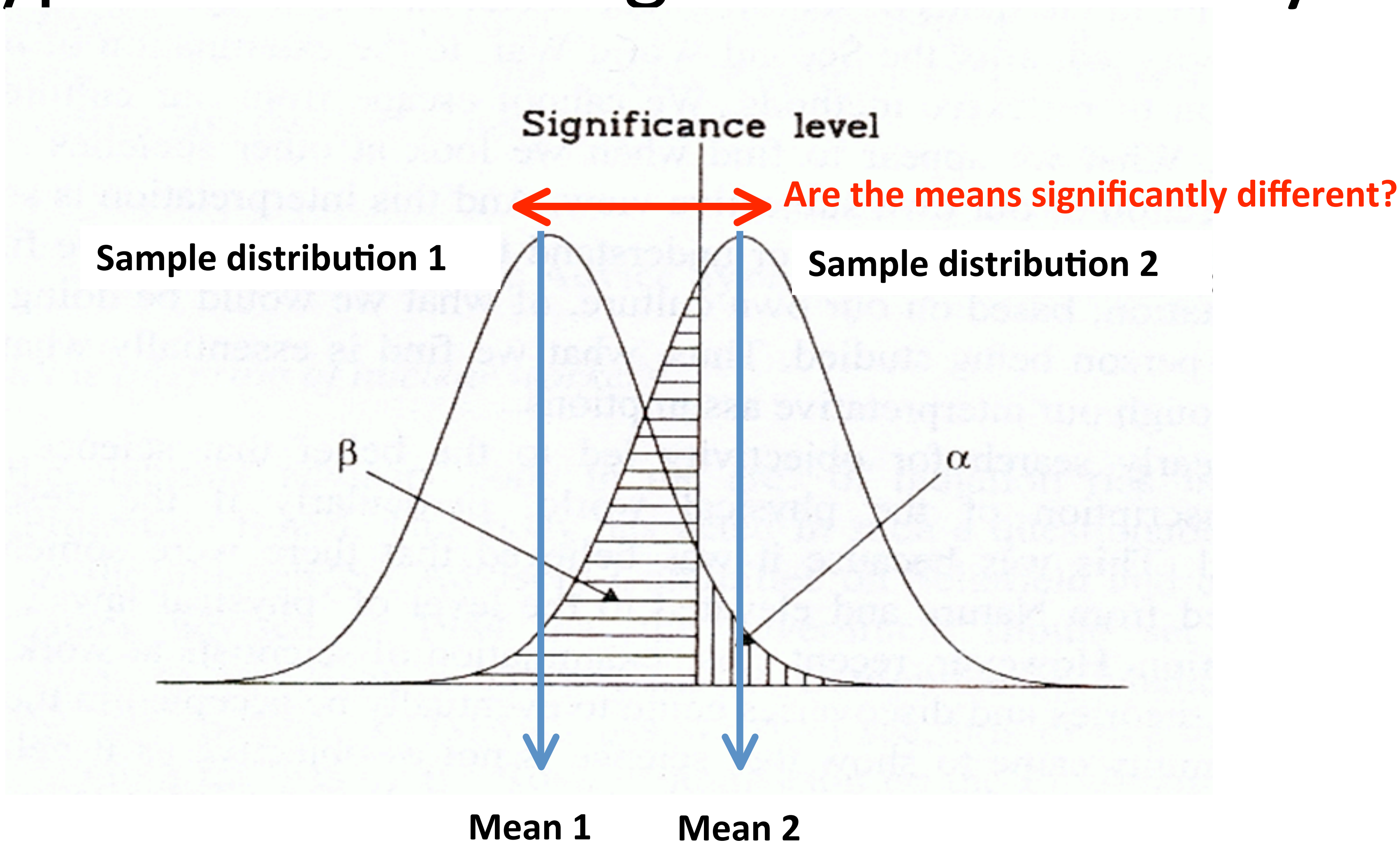
(H_a: $x_2>x_1$ <u>or</u> $x_2-x_1> 0$)

2) Statistical Hypothesis Testing

- **Either** reject or fail to reject the $\mathbf{H_0}$ based on statistical testing
- Statistical testing compares the **p-value** of observed data to an assigned **significance level (α)**
  - **p-value** – the frequency or probability with which the observed event would occur
  - **α** = the probability that the outcome did not occur by chance
    - Popular levels of significance are 5% (0.05), 1% (0.01), and 0.1% (0.001)

IF p-value is **SMALLER** than **α** <u>reject</u> the null hypothesis ($\mathbf{H_0}$)

Hypothesis Testing Visual Summary



Student T-tests

- For this course you are expected to understand and use t-tests
- **<u>T-tests</u>**<u>:</u> used to determine if two sets of data (2 means) are significantly different from each other. It assumes that data is normally distributed and samples are equal.

  – 2 decisions must be made when selecting a t-test:
    - Paired vs. independent
    - 1-tailed vs 2-tailed

3) Selecting T-tests

- **One-sample (paired) t-test:** Compares two samples in cases where each value in one sample has a natural partner in the other (data are not independent). Used on pre/post data . Also compares a sample mean to a specified value
  - Comparing patient performance before and after the application of a drug (repeated measures sampling – the same subjects are measures before and after treatment)

- **Two- sample (Independent) t-test:** compares means for two groups of cases.
  - Comparing patient performance in a group receiving a drug versus a separate group receiving a trial drug

3) Selecting T-tests

- **One-tailed/sided t-test:** expect the effect to be in a certain direction
  - "is the sample mean greater than μ?"
  - "is the sample mean less than μ?"

    $\mathbf{H_0}$: μ = μ_0, where μ_0 is known

    $\mathbf{H_A}$: μ > μ_0 or μ < μ_0

- **Two-tailed/sided t-test:** testing for different means regardless of direction
  - "is there a significant difference?"

    $\mathbf{H_0}$: $\mu_1 = \mu_2$

    $\mathbf{H_A}$: $\mu_1 \neq \mu_2$

Match Your Hypothesis and Test!

A carefully stated experimental hypothesis with indicate the type of effect you are looking for

For example, the hypothesis that

"Coffee improves memory“

– suggests paired, one tailed because you will repeatedly measure the same participants and expect an improvement.

"Men weigh a different amount from women“

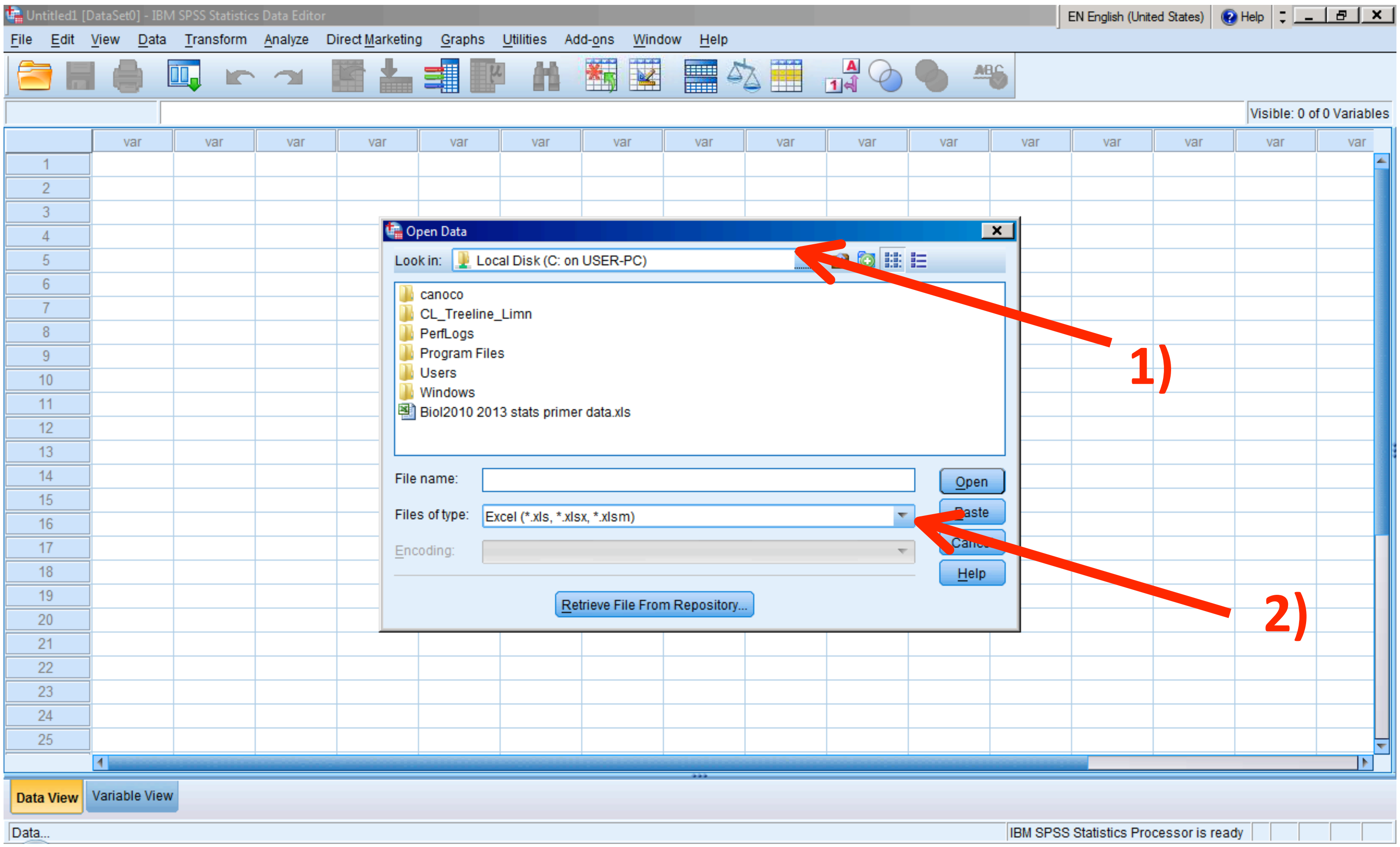
- suggests an independent two tailed test as no direction is implied.

So remember, don't be vague with your hypothesis if you are looking for a specific effect! Be careful with the null hypothesis too - avoid "A does not effect B" if you really mean "A does not improve B".

4) Running a T-test in SPSS

- Question: Do *elodea* and *cabomba* have the same oxygen evolution capability?
- Null hypothesis: $\mu_1 = \mu_2$ (the *elodea* produces the same oxygen output as the *cabomba*)
  - **An independent, 2-tailed test!**
- Alternative hypothesis : $\mu_1 \neq \mu_2$(the *elodea* and *cabomba* 2 DO NOT produce equal amounts of oxygen)

Importing data into SPSS

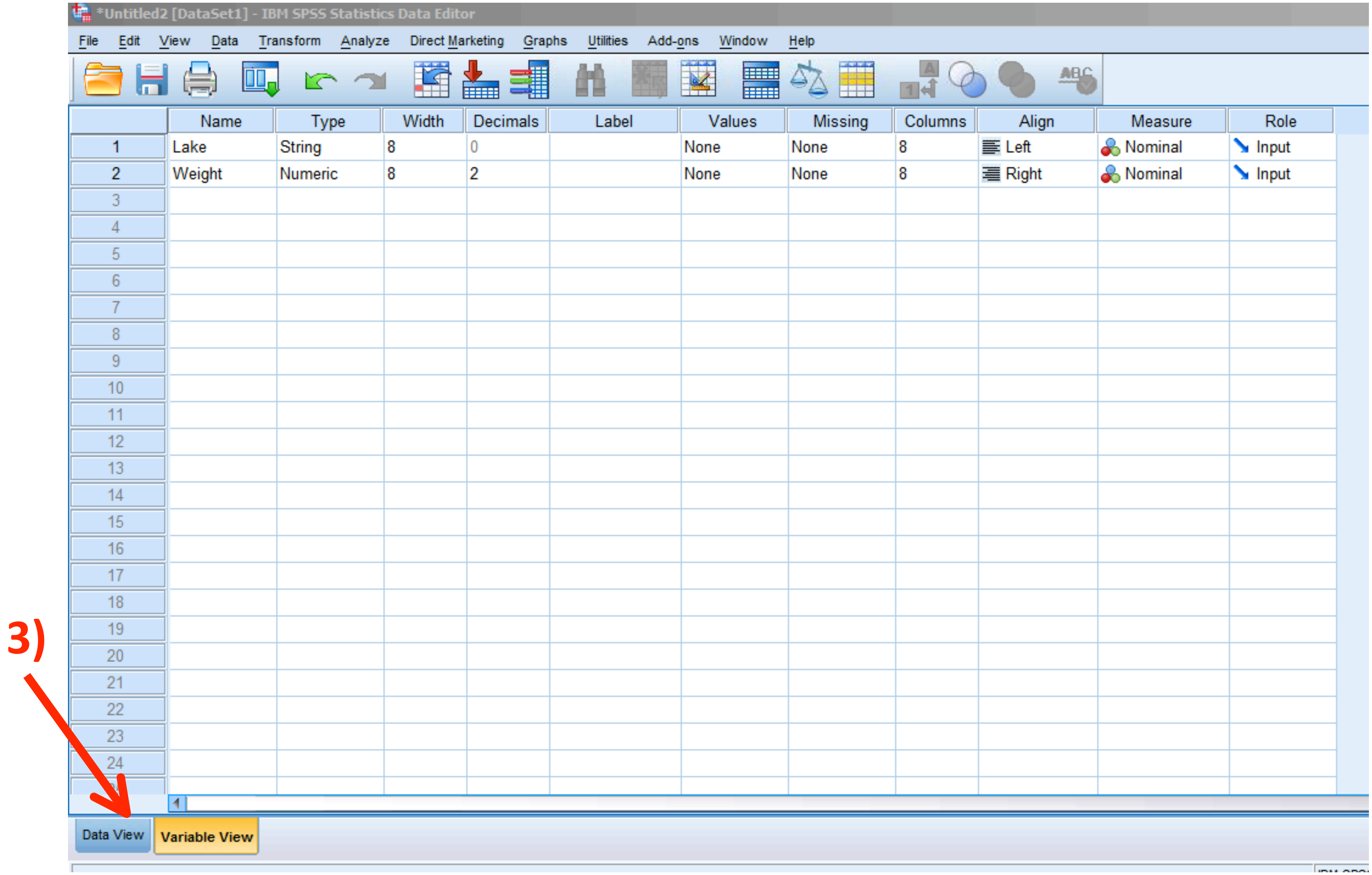


- **Excel spreadsheets can be imported into SPSS**

1) Make sure your spreadsheet is saved on the C: drive of your computer

2) Make sure excel file types are selected

After selecting a file, a window will give you the option of reading Row 1 data as column labels

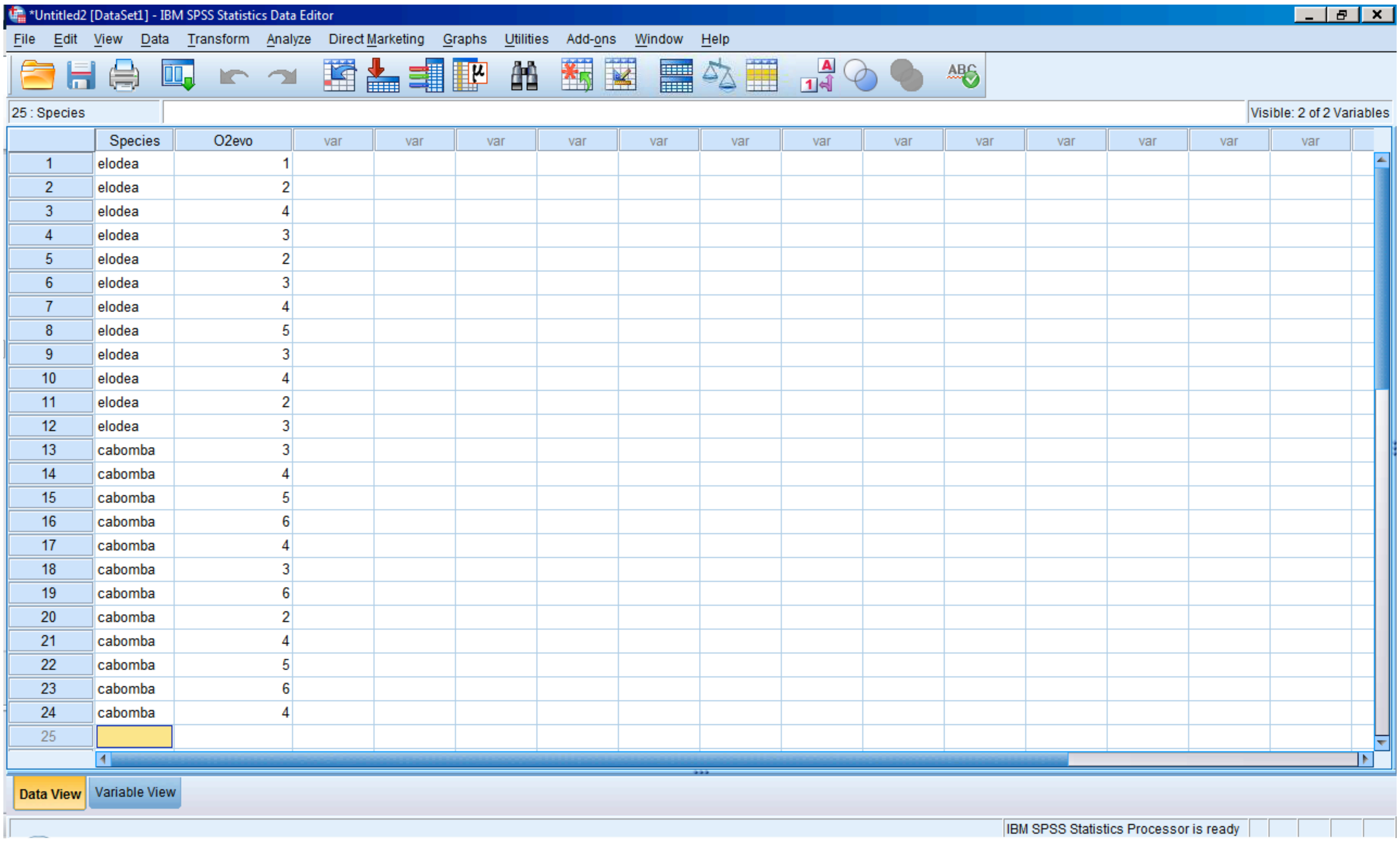


Sometimes will automatically see a summary of your data rather than the data – to correct:

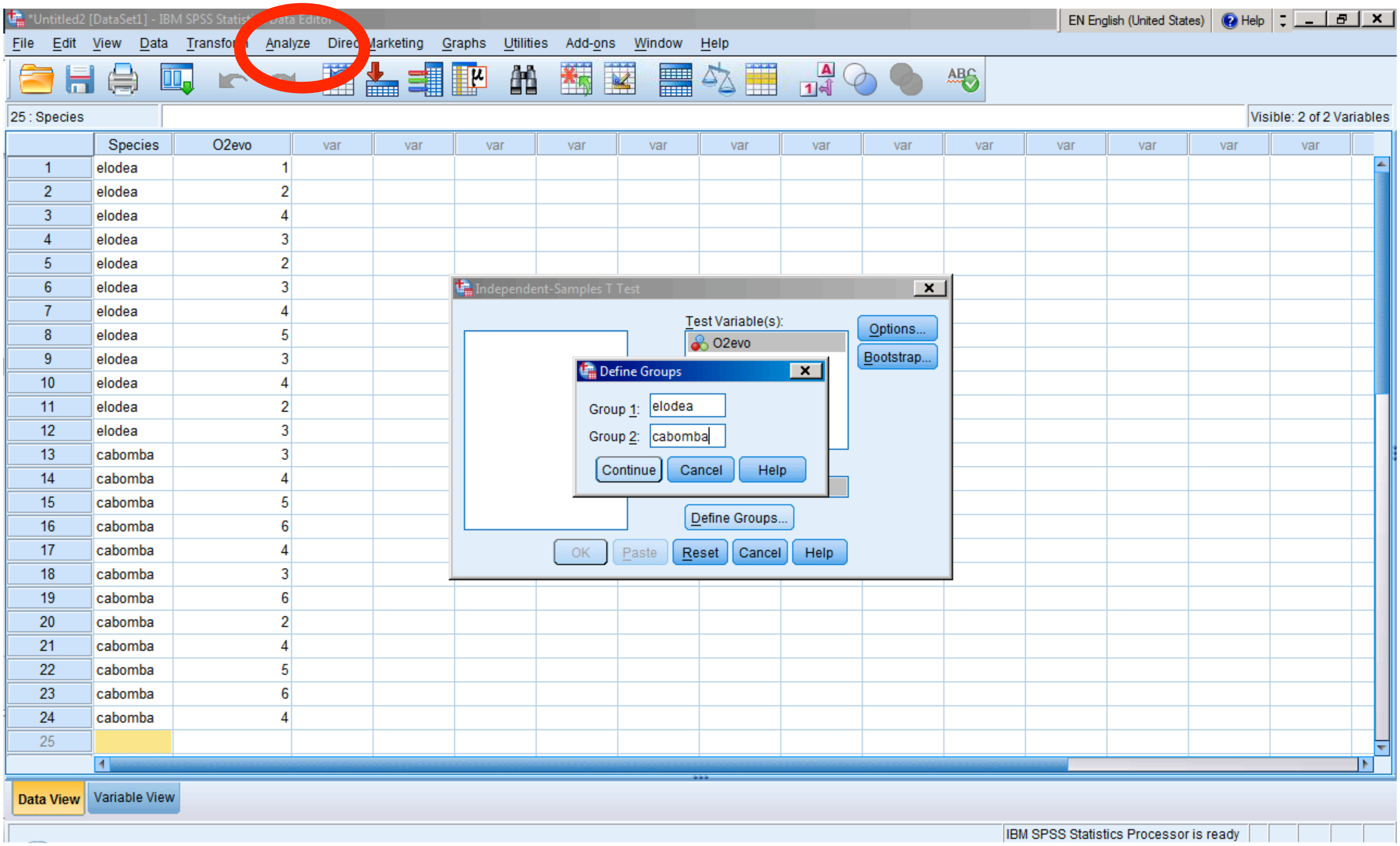
3) Click 'Data view' tab rather than 'Variable view'

Data View / entry

- Notice the variable names in the column headers
- All raw data is listed (SPSS will calculate means for you)
- Data is listed in one column (all with the same units) with the first column indicating the grouping

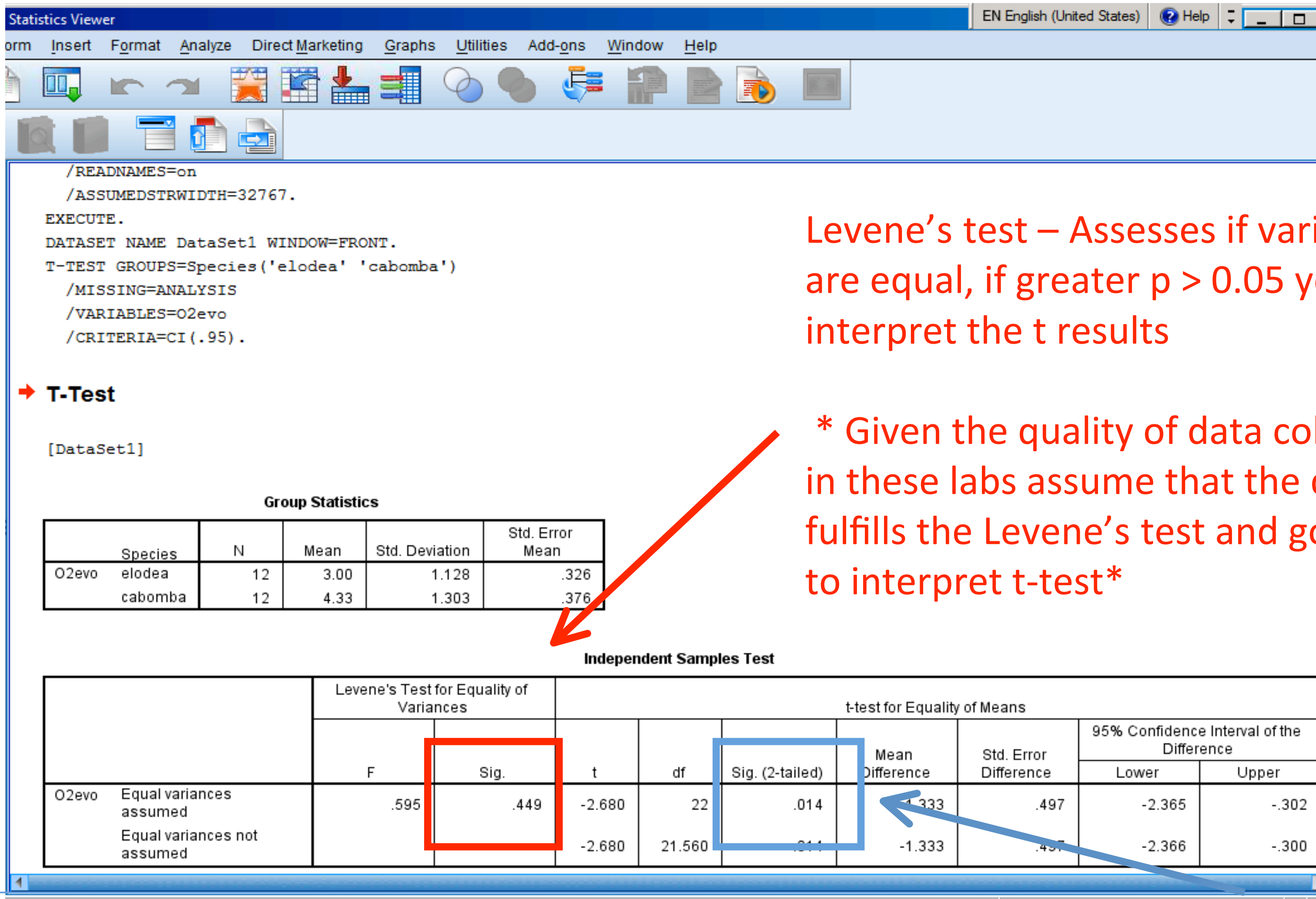


	Species	O2evo	var	var	var	var	var	var	var	var	var	var	var	var	var
1	elodea	1													
2	elodea	2													
3	elodea	4													
4	elodea	3													
5	elodea	2													
6	elodea	3													
7	elodea	4													
8	elodea	5													
9	elodea	3													
10	elodea	4													
11	elodea	2													
12	elodea	3													
13	cabomba	3													
14	cabomba	4													
15	cabomba	5													
16	cabomba	6													
17	cabomba	4													
18	cabomba	3													
19	cabomba	6													
20	cabomba	2													
21	cabomba	4													
22	cabomba	5													
23	cabomba	6													
24	cabomba	4													
25															



Select Analyze → compare means → independent samples t test
O2evo is the test variable
Species is the grouping variable (Click on define groups and type the two names used in the data view)
NOTE - If you are having trouble with SPSS, YouTube has many short trouble shooting videos that are quite helpful.

<u>Output</u>




```
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
T-TEST GROUPS=Species('elodea' 'cabomba')
  /MISSING=ANALYSIS
  /VARIABLES=O2evo
  /CRITERIA=CI(.95).
```

T-Test

[DataSet1]

Group Statistics

	Species	N	Mean	Std. Deviation	Std. Error Mean
O2evo	elodea	12	3.00	1.128	.326
	cabomba	12	4.33	1.303	.376

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
O2evo	Equal variances assumed	.595	.449	-2.680	22	.014	-1.333	.497	-2.365	-.302
	Equal variances not assumed			-2.680	21.560	.014	-1.333	.497	-2.366	-.300

Levene's test – Assesses if variances are equal, if greater p > 0.05 you can interpret the t results

* Given the quality of data collected in these labs assume that the data fulfills the Levene's test and go on to interpret t-test*

Our example: Levene's (p = 0.449) so we can interpret the **t-test (p = 0.014)** so we can reject the null hypothesis, thus the *elodea* and *cabomba* **DO NOT** produce equal amounts of oxygen.

- The sig. level may sometimes read 0.000 indicating that the p-value is <0.001. This simply indicates a highly significant result.

5) How to report T-test results

- All performed statistics <u>MUST</u> be referred to in the text of your report.
- You must indicate:
  - the type of test performed,
  - the data the test was performed on,
  - The α level used (0.05 by default)
  - The p-value outcome of your test
  - Whether you accept or reject the null hypothesis.

Ex.

> "An independent, 2-tailed t-test was performed comparing mean O2 production from *elodea* and *cabomba*. A significant difference ($\alpha = 0.05$, $p=0.014$) in production was found between species and we therefore reject the null hypothesis of this experiment."

- **For purposes of this course you are required to take a print screen of your SPSS output (as in the previous slide) and attach this in your report.**

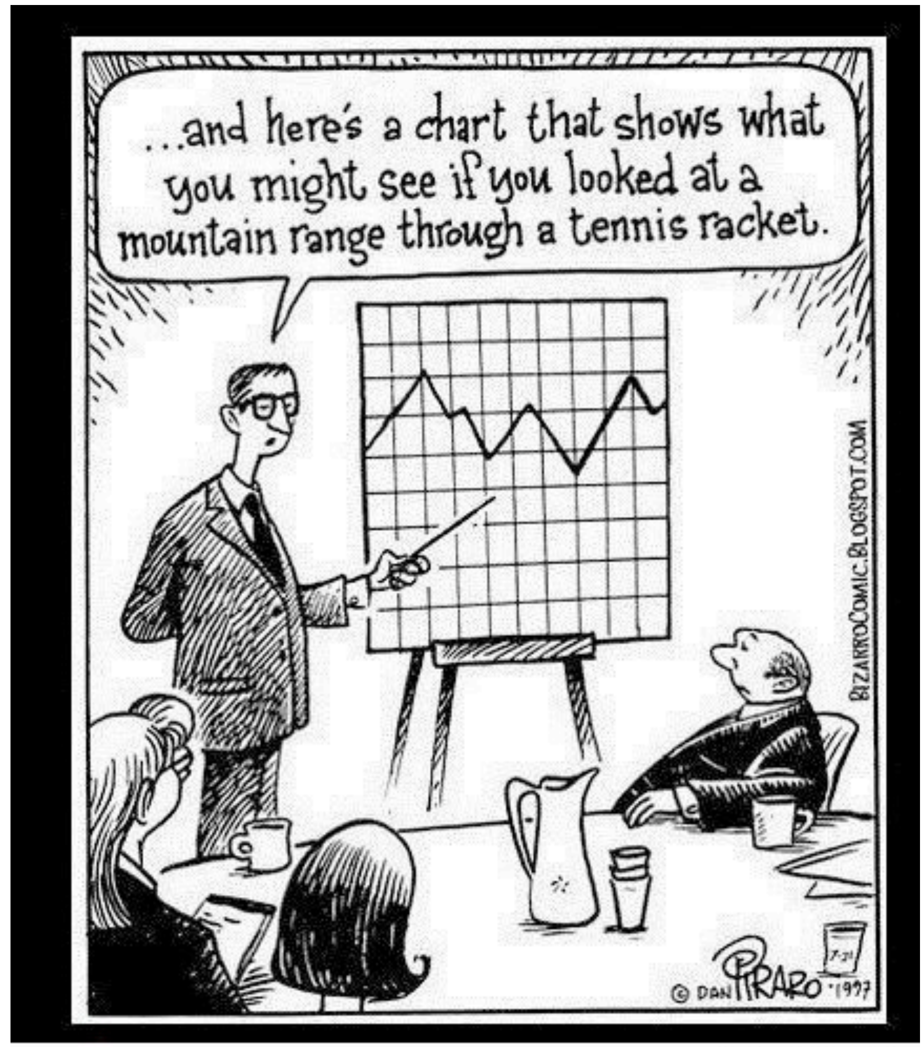
6) Choosing Graphs

Your hypothesis and statistical test should guide your choice of figures!

- Some tests are related to specific figures
  - Correlations and Scatter plots

The following slides outline the basic use of several common graphs

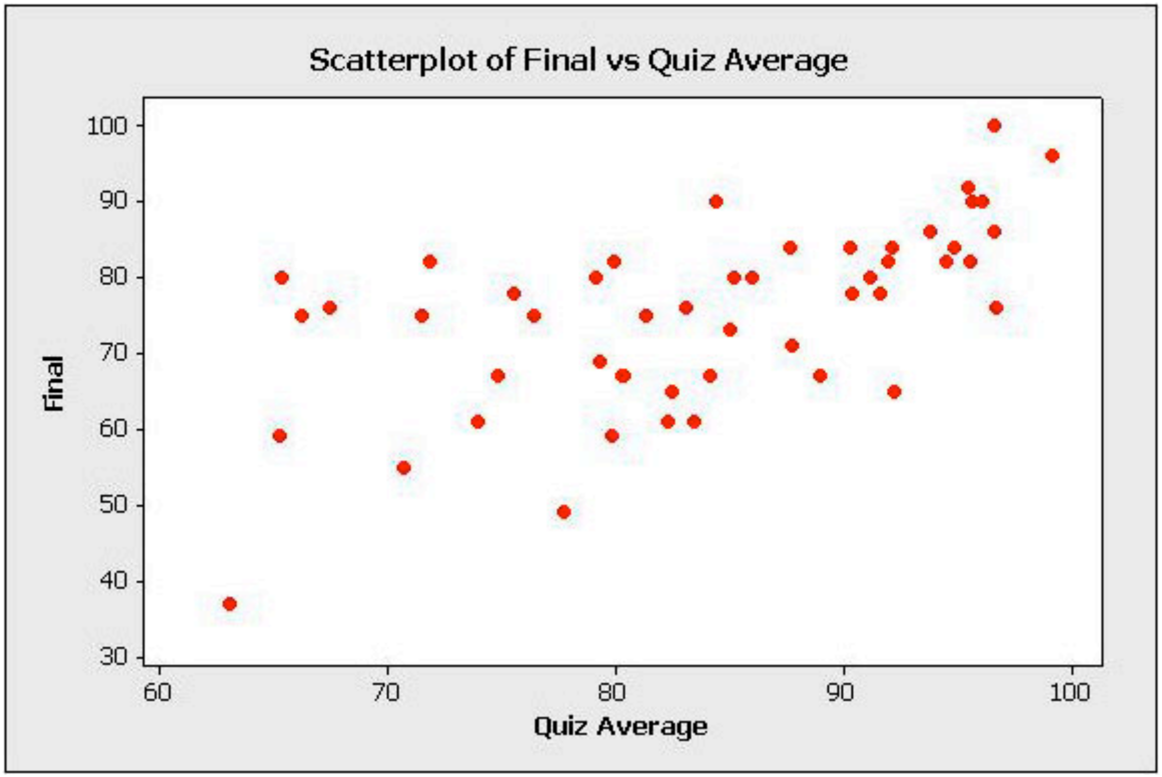
- Scatter plots
- Line Graphs
- Bar graphs
- Histograms



WeKnowMemes

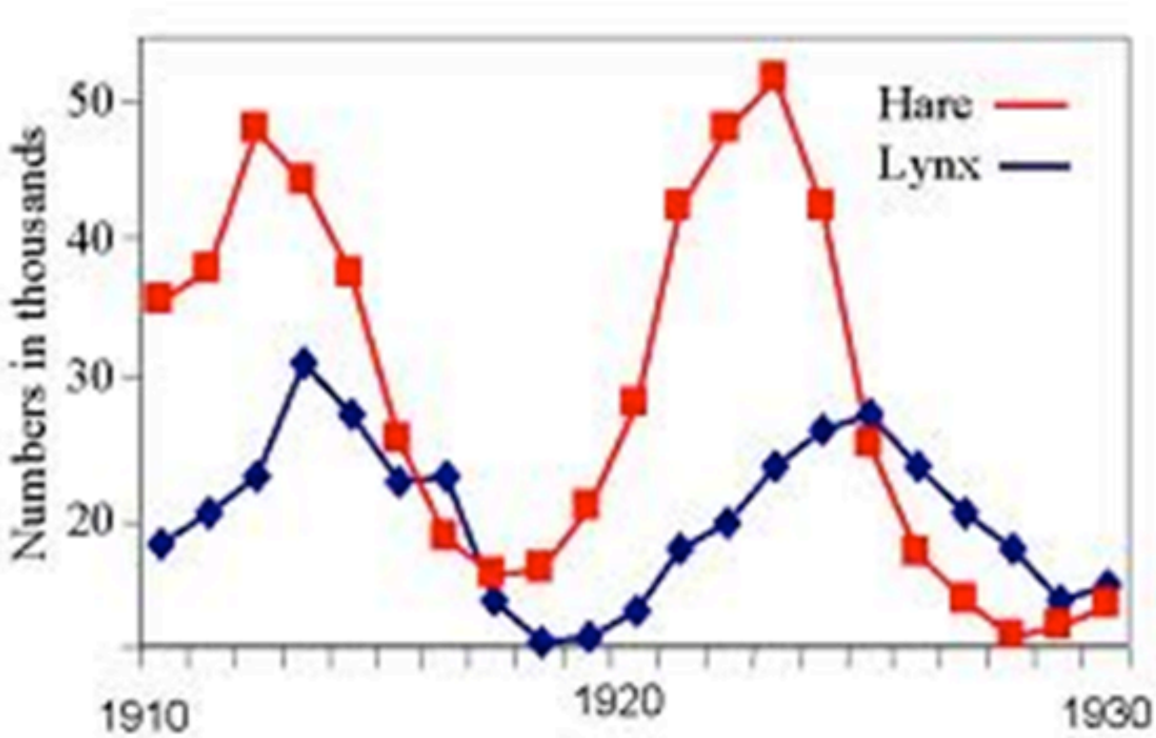
Scatter plot

- Displays 2 variables for a set of data
- Dependant vs. independent – one variable is under the control of the other variable



Line graph

- Shows relationship between values plotted on each axis (dependant vs. independent)
  - Used on continuous variables

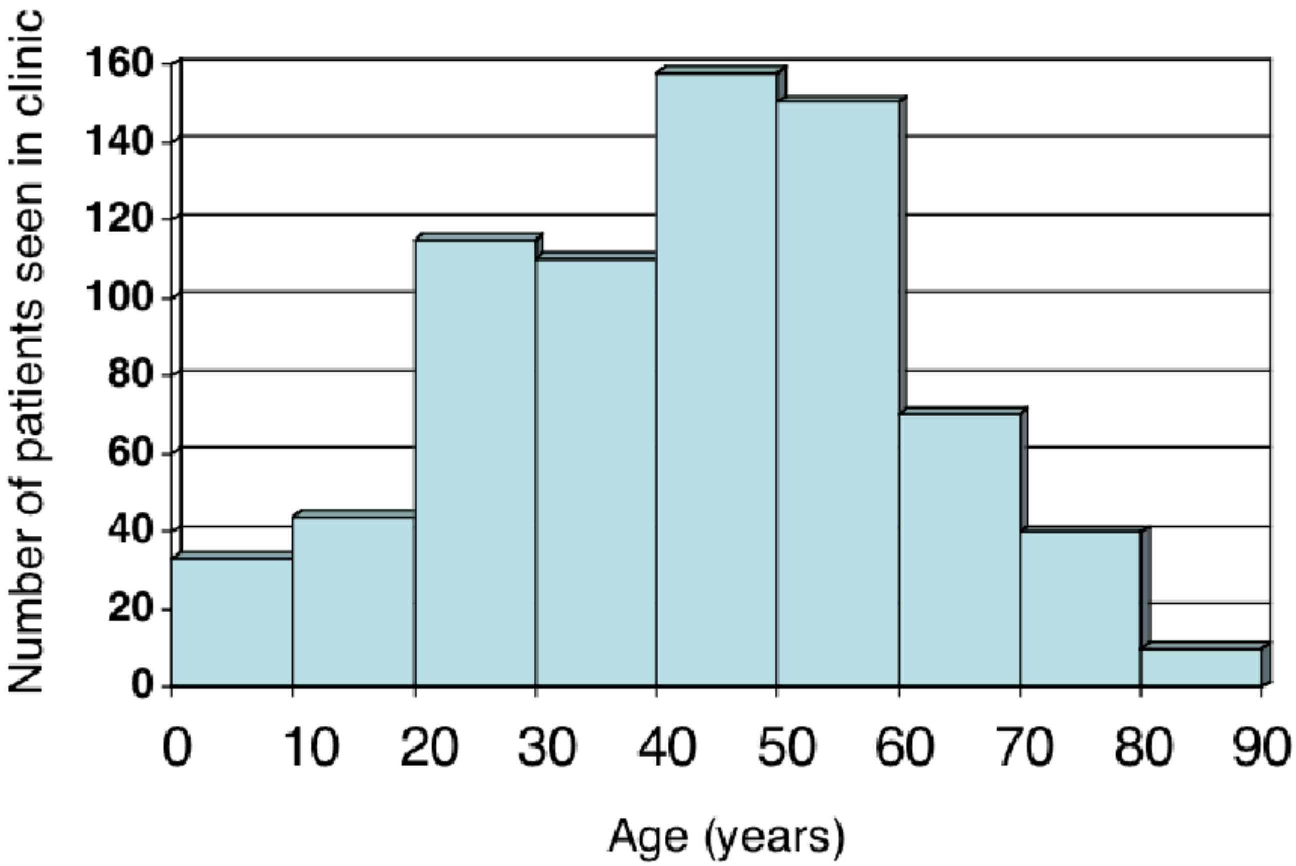


Bar graph

- Used for discreet quantitative variables which are similar but not necessarily related
- Often used to display t-test results

Histogram

- Used exclusively for showing the distribution of data that are continuous.



Conclusion

- This tutorial has provided you with the basic theory, mechanics and applications of common statistical tests.
- You should now be able to carry out scientific reporting from hypothesis formation to statistical testing and figure formatting.