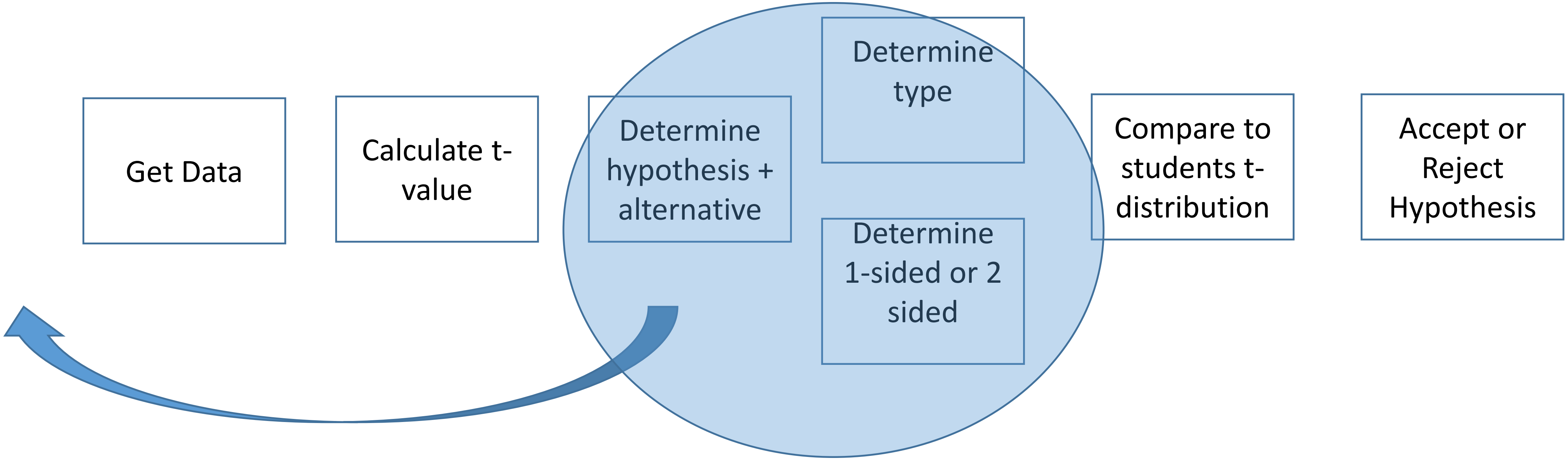
t-value and student’s t-test

by Alex Dance

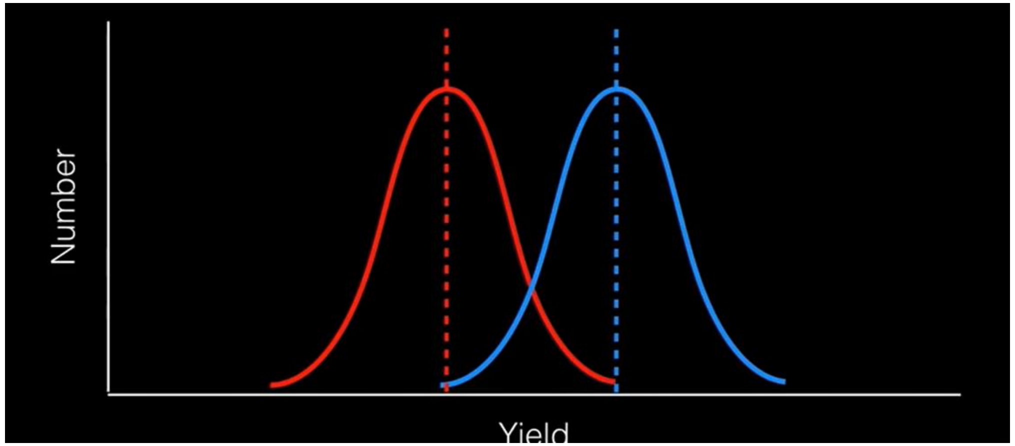
Comparing the yield of 2 fields with a mean is easy but it doesn't tell us much

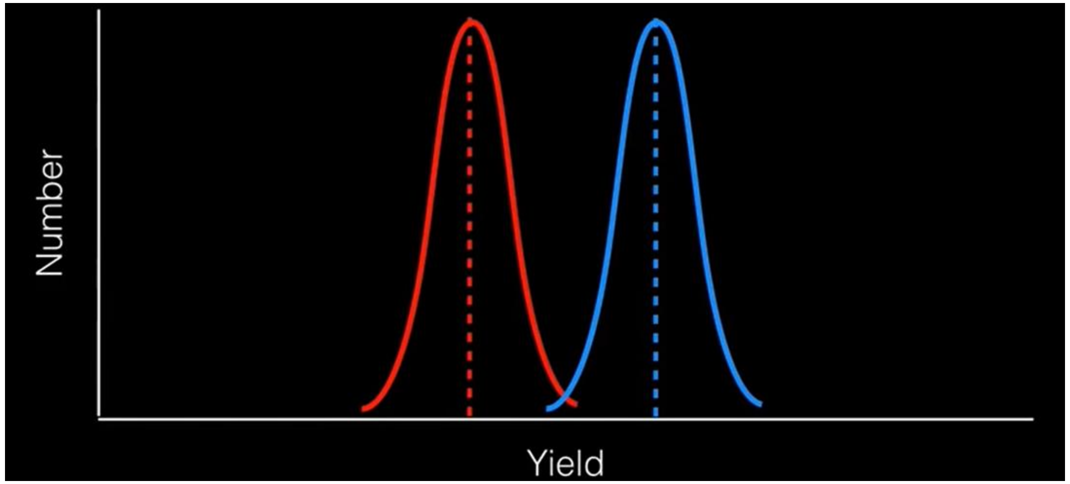
	Field 1	Field 2	Difference
Mean of Yield	15.38	15.68	2%

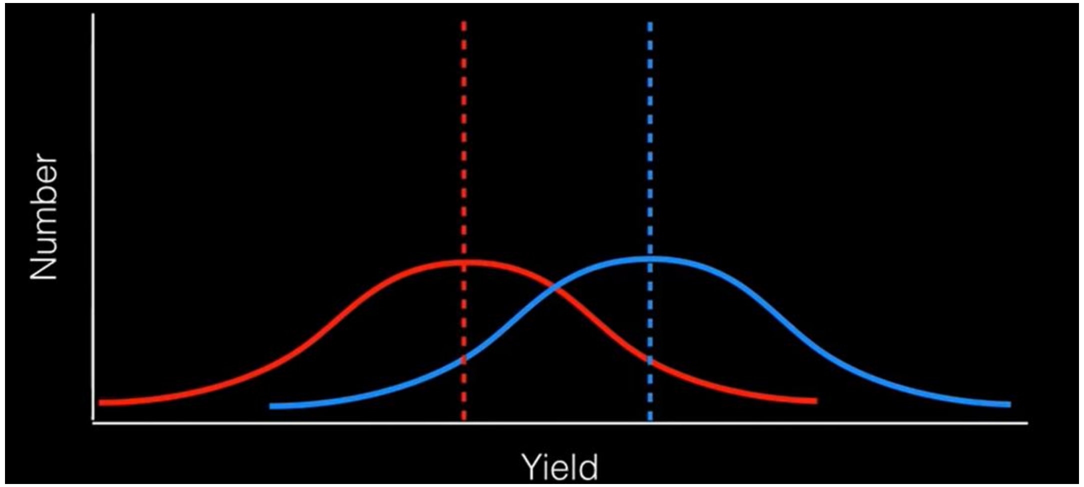
Steps in going through a t-value and t-test



For our particular sample we don't know if the spread is large or not







The greater the t-value
THEN
the more likely it is that your data are significantly separated

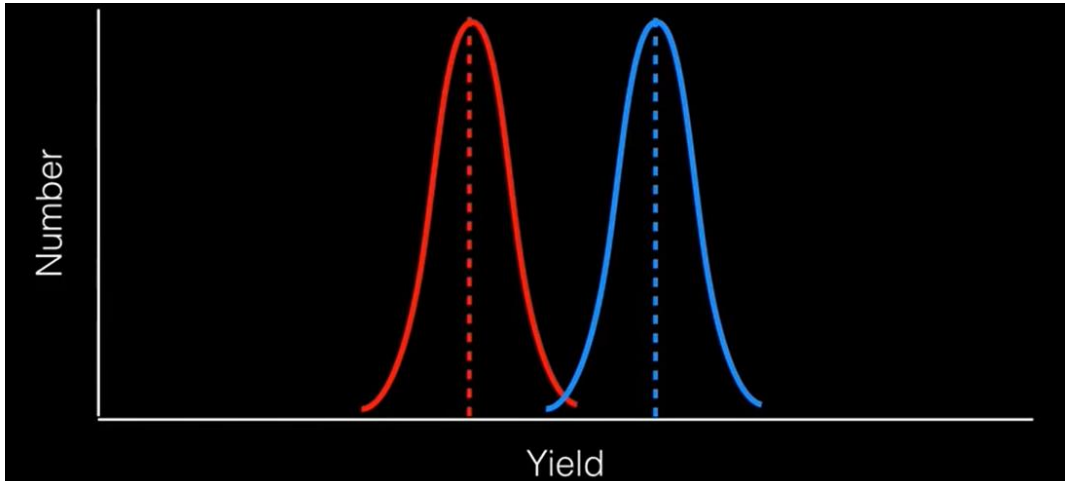
The greater the difference in means the greater the numerator and the greater the t-value

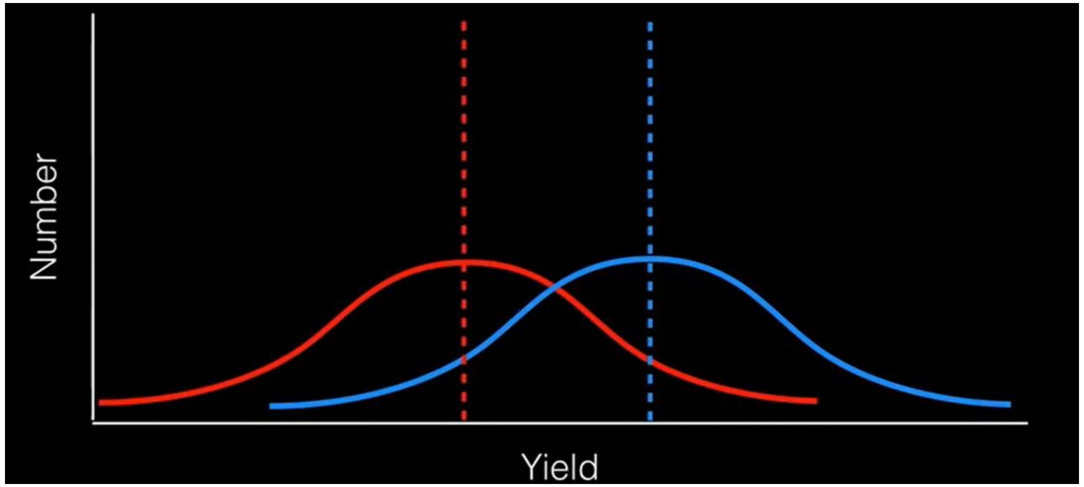
$$\text{t-value} = \frac{\overline{x1} - \overline{x2}}{\sqrt{\frac{s1^2}{n1} + \frac{s2^2}{n2}}}$$

The greater the standard deviation the greater the denominator and the smaller the t-value

The greater the t-value
THEN
the more likely it is that your data are significantly separated

	Large	Small
Means variation	Larger t-value	Smaller t-value
Standard deviation	Smaller t-value	Larger t-value
Number of units	Larger t-value	Smaller t-value





Plugging the numbers into a formula is relatively easy and highlights the differences

	Field 1	Field 2	Difference
Mean	15.38	15.68	2%
StDev	0.31	0.41	32%
Variance (std dev squared)	0.097	0.165	70%
number	16	16	

$$\text{t-value} = \frac{\overline{x1} - \overline{x2}}{\sqrt{\frac{s1^2}{n1} + \frac{s2^2}{n2}}}$$

$$\text{t-value} = \frac{15.38 - 15.68}{\sqrt{\frac{.097}{16} + 0.165/16}}$$

t-value = 0.3 / 0.13 = 2.3

Our hypothesis is based on the t-value being above or below a critical value in student t-test

If t-value is **below** a Critical Value we do NOT reject the null Hypothesis
VS
If t-value is **above** a Critical Value we DO reject the null Hypothesis
and therefore
accept the Alternate Hypothesis

t-value =2.3

H0 (Null Hypothesis)
There is
NO
statistically significant
difference between the samples

H1 (Alternate Hypothesis)
Reject and therefore (opposite)
IS A
statistically significant
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Plug into a 2-sided t-table for a student's test

df or degrees of freedom
= n1 + n2 -2
=16 + 16 -2
=30

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	0.50	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
two-tails	1.00	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.002	0.001
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.000	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.000	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
1000	0.000	0.675	0.842	1.037	1.282	1.646	1.962	2.330	2.581	3.098	3.300
z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	Confidence Level										

Our hypothesis is based on the t-value being above or below a critical value

t-value =2.3

At 5%
Table gives 2.04 at 5%

At 5 % means the corollary.
100% - 5% = 95%
Therefore 95% sure

If t-value is **below** a Critical Value we do NOT reject the null Hypothesis
VS
If t-value is **above** a Critical Value we DO reject the null Hypothesis
and therefore
accept the Alternate Hypothesis

t-value =2.3

At 1%
table 3.64 at 1%

H0 (Null Hypothesis)
There is
NO
statistically significant
difference between the samples

H1 (Alternate Hypothesis)
Reject and therefore (opposite)
IS A
statistically significant
difference between the samples

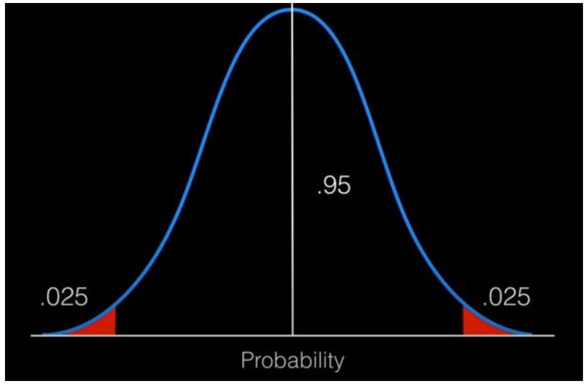
This was an unpaired, 2-sided, independent test, which means we are testing independent fields

Alternative is paired samples which is used if sampling the same population twice.

Number of criteria for running a t-test

- Normal distributions in both samples
- Similar variance
- Roughly the same number of data points
- Generally under 30 data points

Most tests are 2-sided

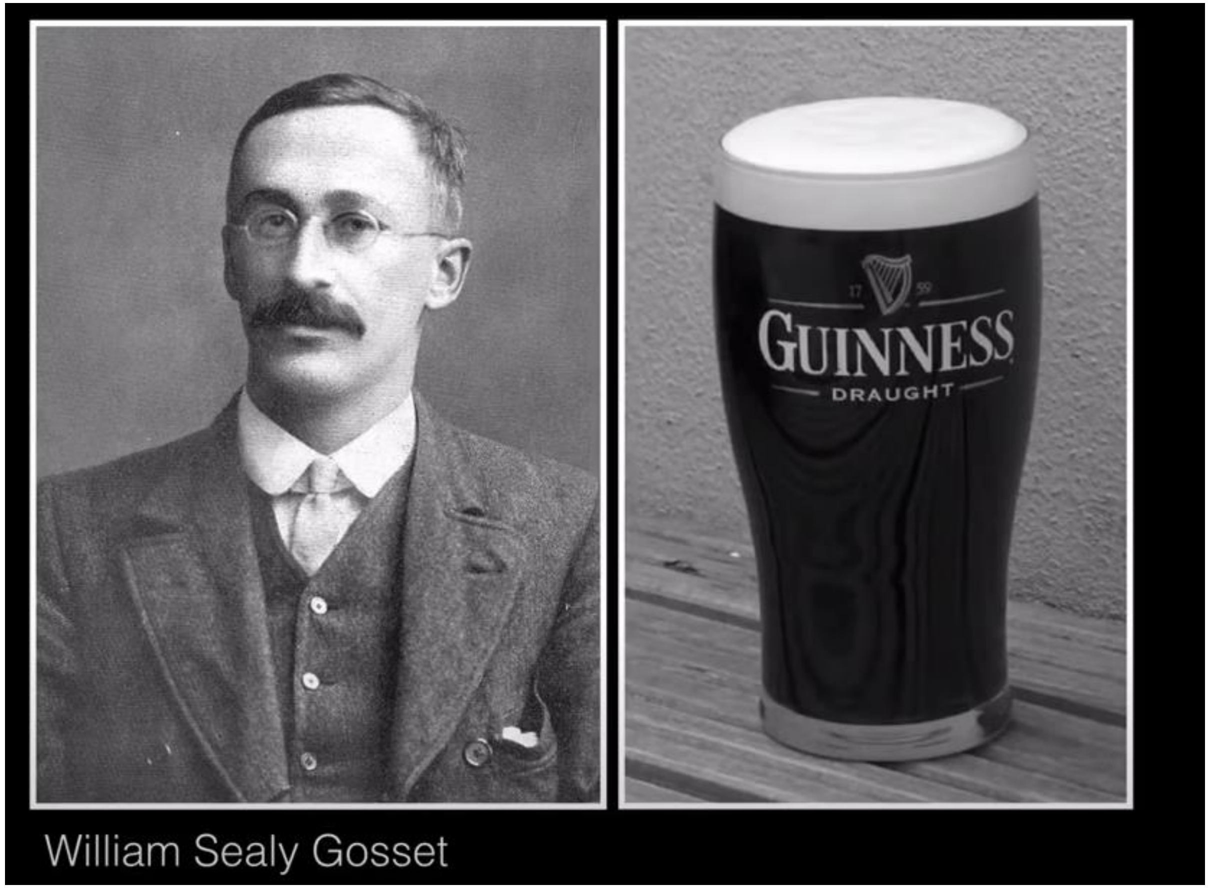


- Select the one-tailed test when the consequences of missing an effect are negligible

- When using a one-tailed test, you are testing for the possibility of the relationship in one direction and completely disregarding the possibility of a relationship in the other direction.

- Choosing a one-tailed test for the sole purpose of attaining significance is not appropriate.
- Imagine you have developed a new drug that you believe is an improvement over an existing drug. You wish to maximize your ability to detect the improvement, so you opt for a one-tailed test. In doing so, you fail to test for the possibility that the new drug is less effective than the existing drug. The consequences in this example are extreme, but they illustrate a danger of inappropriate use of a one-tailed test.

Drink Guinness when doing a t-test



William Sealy Gosset

THE PROBABLE ERROR OF A MEAN

BY STUDENT

Introduction

Any experiment may he regarded as forming an individual of a "populatic

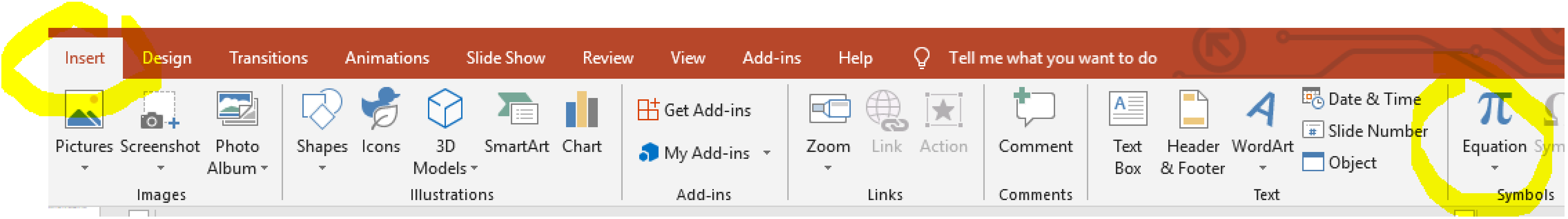
Python code

help (ttest_rel)

```
# Example of the Paired Student's t-test
from scipy.stats import ttest_rel
data1 = [0.873, 2.817, 0.121, -0.945, -0.055, -1.436, 0.360, -1.478, -1.637, -1.869]
data2 = [1.142, -0.432, -0.938, -0.729, -0.846, -0.157, 0.500, 1.183, -1.075, -0.169]
stat, p = ttest_rel(data1, data2)
print('stat=%.3f, p=%.3f' % (stat, p))
if p > 0.05:
   print('Same distribution')
else:
   print('Different distributions')
```

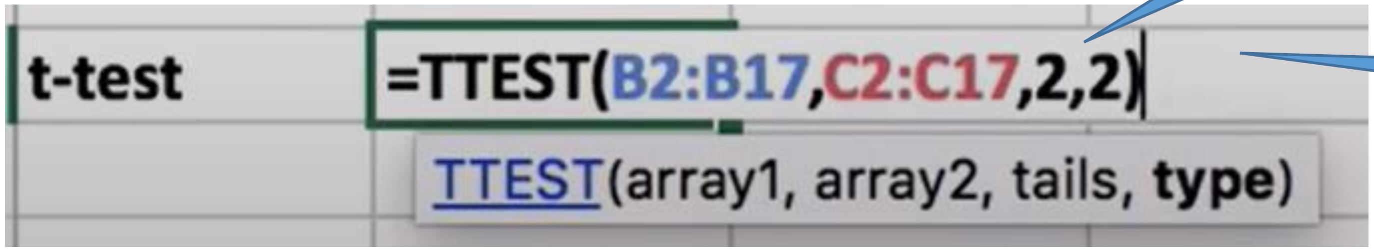
```
Notes ----- Examples for use are
scores of the same set of student in
different exams, or repeated
sampling from the same units. The
test measures whether the average
score differs significantly across
samples (e.g. exams). If we observe
a large p-value, for example greater
than 0.05 or 0.1 then we cannot
reject the null hypothesis of
identical average scores. If the p-
value is smaller than the threshold,
e.g. 1%, 5% or 10%, then we reject
the null hypothesis of equal
averages. Small p-values are
associated with large t-statistics.
```

Powerpoint Tip

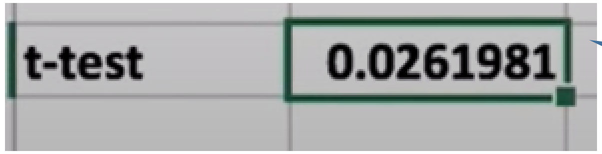


Excel Tip

2 tails



Type 2 is independent



This means we are 2.6% sure it is significantly different

This is just 1 of many tests – only some tests listed below

Parametric Statistical Hypothesis Tests
- Student’s t-test
- Paired Student’s t-test
- Analysis of Variance Test (ANOVA)
- Repeated Measures ANOVA Test

Nonparametric Statistical Hypothesis Tests
- Mann-Whitney U Test
- Wilcoxon Signed-Rank Test
- Kruskal-Wallis H Test
- Friedman Test

Normality Tests
- Shapiro-Wilk Test
- D’Agostino’s K^2 Test
- Anderson-Darling Test

Correlation Tests
- Pearson’s Correlation Coefficient
- Spearman’s Rank Correlation
- Kendall’s Rank Correlation
- Chi-Squared Test

Stationary Tests
- Augmented Dickey-Fuller
- Kwiatkowski-Phillips-Schmidt-Shin

Thanks

Alex Dance

Background

- Maths / statistics degree
- Background in big data, strategy, analytics
- Worked at Optus, Salmat, Reuters, Pathfinder Solutions

Copy of This Presentation and code

https://github.com/alexdance2468/

Plus other data science projects completed

Contact Details

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Thanks

Sources:
https://www.youtube.com/watch?v=pTmLQvMM-1M
https://machinelearningmastery.com/statistical-hypothesis-tests-in-python-cheat-sheet/
https://en.wikipedia.org/wiki/Student%27s_t-test