Statistical Test: T-Tests

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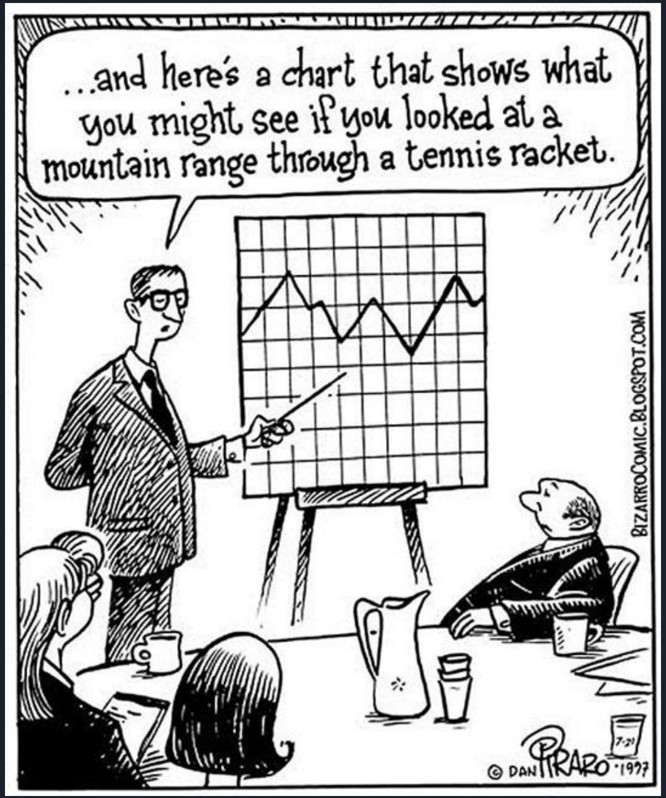
Agenda

1. Why do we need these tests?
2. The different types of t-tests:
   a. One Sample t-test
   b. Paired t-test
   c. Two Sample t-test
3. Vocabulary and Concepts
4. Types of Errors
5. Example data set and practice
6. Journal Article



Why is it needed and when to use it

- Used to compare means of data
- Shows if there are significant differences
- 3 different versions of the tests for different types of comparisons

- Can use when…
    - Data is a random sample from a population
    - Sample size is less than 10%
    - There is a normal distribution

One Sample T-test

- Compares the mean of a data set to a known value

Good to use when…

- Population standard deviation is unknown
- Small sample size

Paired T-test

- Used to compare means of dependent samples
- When measurements are taken from the same item, person, or thing
- Data gathered from tests with unique conditions

Paired T-test Examples

- When testing on the same people before and after a change

- Testing different equipment on the same subject

- Cost of the same items in different locations

Two Sample T-test

- Used to compare means of independent samples
- Need random samples from both groups
- Starts with a null hypothesis that assumes that the means of both data sets are equal

Types of Errors that Can Occur

- Type 1 Error
  - Incorrectly rejecting your null hypothesis
  - “False Positive”
  - α = The probability of committing this kind of error
- Type 2 Error
  - Failing to reject a false null hypothesis
  - β = The probability of committing this kind of error

PHANTOMS!!! P-Parameters

https://1drv.ms/x/s!Apwp-FdNSstjixlB_ucujGvScu4j

- μ_J = Mean of mpg for Japanese Cars = 15.864
- μ_A = Mean of mpg for American Cars = 30.636
- n_J = Sample Size of mpg for Japanese Cars = 88
- n_A = Sample Size of mpg for American Cars = 88
- s_J = Standard Deviation of mpg for Japanese Cars = 4.063
- s_A = Standard Deviation of mpg for American Cars = 5.973

H - Hypothesis

- Null Hypothesis
  - $H_0: \mu_J = \mu_A$

- Alternative Hypothesis (Two-tailed)
  - $H_A: \mu_J \neq \mu_A$

- One-Tailed Hypothesis
    - Testing the statistical significance in one direction only
    - $\mu_1 > \mu_2$ OR $\mu_1 < \mu_2$

- Two-Tailed Hypothesis
    - Testing the statistical significance of the data in two directions
    - $\mu_1 \neq \mu_2$

A - Assumptions

- Independence
  - American cars and Japanese cars are independent of each other
  - Each value within the groups is independent of one another
- Nearly Normal
  - https://1drv.ms/x/s!Apwp-FdNSstjixlB_ucujGvScu4j
- Sample Less than 10% of the population
  - 880 cars is less than the population of American or Japanese cars
- Random
  - All data has been randomly selected

N - Name that Test!

- Two Samples that have no dependence upon each other

- We have the means of the two samples
  - Two - Sample T- Test

T - Testing

$$t = \frac{\mu_J - \mu_A}{\sqrt{\frac{s_J^2}{n_J} + \frac{s_A^2}{n_A}}} = \frac{15.864 - 30.636}{\sqrt{\frac{4.063^2}{88} + \frac{5.973^2}{88}}} = -19.1827$$

O - Obtain P-value

- How to complete a t-test
  - Find p - value
  - Can use a t-table or a calculator
  - P - value here is 0

df/p	0.40	0.25	0.10	0.05	0.025	0.01	0.005	0.0005
1	0.324920	1.000000	3.077684	6.313752	12.70620	31.82052	63.65674	636.6192
2	0.288675	0.816497	1.885618	2.919986	4.30265	6.96456	9.92484	31.5991
3	0.276671	0.764892	1.637744	2.353363	3.18245	4.54070	5.84091	12.9240
4	0.270722	0.740697	1.533206	2.131847	2.77645	3.74695	4.60409	8.6103
5	0.267181	0.726687	1.475884	2.015048	2.57058	3.36493	4.03214	6.8688
6	0.264835	0.717558	1.439756	1.943180	2.44691	3.14267	3.70743	5.9588
7	0.263167	0.711142	1.414924	1.894579	2.36462	2.99795	3.49948	5.4079
8	0.261921	0.706387	1.396815	1.859548	2.30600	2.89646	3.35539	5.0413
9	0.260955	0.702722	1.383029	1.833113	2.26216	2.82144	3.24984	4.7809
10	0.260185	0.699812	1.372184	1.812461	2.22814	2.76377	3.16927	4.5869
11	0.259556	0.697445	1.363430	1.795885	2.20099	2.71808	3.10581	4.4370
12	0.259033	0.695483	1.356217	1.782288	2.17881	2.68100	3.05454	43178
13	0.258591	0.693829	1.350171	1.770933	2.16037	2.65031	3.01228	4.2208
14	0.258213	0.692417	1.345030	1.761310	2.14479	2.62449	2.97684	4.1405
15	0.257885	0.691197	1.340606	1.753050	2.13145	2.60248	2.94671	4.0728
16	0.257599	0.690132	1.336757	1.745884	2.11991	2.58349	2.92078	4.0150
17	0.257347	0.689195	1.333379	1.739607	2.10982	2.56693	2.89823	3.9651

M - Make a Decision

- Level of significance - $\alpha = 0.05$

- $p < \alpha$ - statistically significant difference

S - Statement/Solution

- We reject the null hypothesis that the average miles per gallon for American and Japanese cars is equivalent, as there was a statistically significant difference amongst the means, and our p-value of 0, is less than the α that was established.

Example from a Journal Article:

- 60% of the population has Rhythmic Masticatory Muscle Activity
- Tooth-grinding during sleep, called sleep bruxism, is found in 6 to 8% of the population
- This article has looked at whether they are more prevalent in people with sleep bruxism.
- These are two-sample t tests because these are two independent groups

Table 2. Rhythmic Masticatory Muscle Activity (RMMA) and Sleep Variables in 31 Normal Subjects with RMMA Age- and Gender-matched with 33 Sleep Bruxers

Variable	Normal Subjects with RMMA	Sleep Bruxers	p
Subjects			
Sex distribution	61.3% M; 38.7% F	54.5% M; 45.5% F	0.59[b]
Age	27.6 ± 1.4 [15-40][a]	26.8 ± 1.0 [20-50]	0.66
RMMA episodes			
Number/hr	1.8 ± 0.5 [0.1-12.6]	5.8 ± 0.5 [1.2-15.2]	<0.0001
Episodes with noise (%)	0	33.1 ± 5.1	
Sleep variables			
Sleep duration (min)	454.7 ± 6.3	454.5 ± 7.8	0.98
Sleep efficiency (%)	93.4 ± 0.8	94.7 ± 0.7	0.21
Awakenings/hr	3.8 ± 0.3	3.5 ± 0.4	0.55
Microarousals/hr	5.7 [2.0-24.7]	9.5 [2.2-21.9][d]	0.007[c]
Stage 1 (%)	10.1 ± 0.8	10.8 ± 0.7	0.55
Stage 2 (%)	55.9 ± 1.3	57.0 ± 1.4	0.59
Stages 3 + 4 (%)	13.1 ± 1.5	12.1 ± 1.4	0.64
REM (%)	20.9 ± 0.9	20.0 ± 0.9	0.49

a Mean ± SEM or median [min max].
b Pearson chi-square.
c Mann-Whitney U test; otherwise, two-sample *t* test.
d Calculations for microarousals were based on 29 patients with sleep bruxism, since four were recorded on paper only.

Significant Results & Interpretation

RMMA episodes	Normal Subjects w/ RMMA	Sleep Bruxers	P-value
Number/hr	1.8 ± 0.5 [0.1-12.6]	5.8 ± 0.5 [1.2-15.2]	<0.0001
Episodes with noise (%)	0	33.1 ± 5.1	

At an alpha level of 0.05, we can reject the null hypothesis and conclude that sleep bruxers have more RMMA episodes than normal subjects.

References

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