Two-Sample t-test
Dependent Samples

Course: Statistics 1

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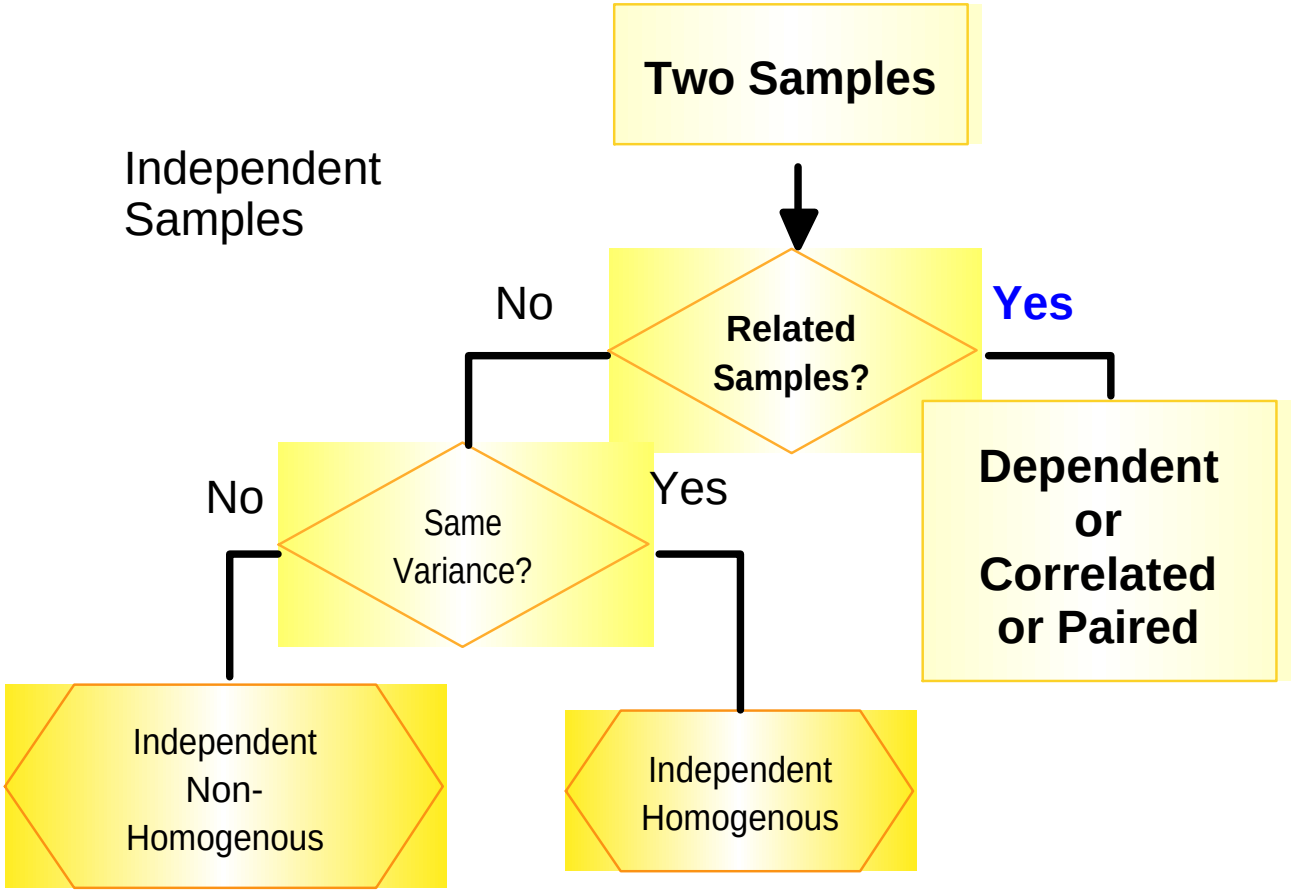
Example

- Examples:
  - Pretest-Posttest studies
  - Husband/wives studies
  - Twin studies
- Case:
  - Dependent Samples: Correlated Samples
  - Sample: Cars' MPG with and without additives

Sample

Car	With Additive	Without Additive	*d*
1	35	38	-3
2	40	39	1
3	42	40	2
4	34	40	-6
5	46	46	0
6	32	37	-5
7	32	36	-4
8	40	38	2
9	45	43	2
10	46	47	-1
Mean	**39.2**	**40.4**	**-1.2**
SD	5.613476	3.747592	S_d **= 3.08**

Dependent Samples



Step 1: Hypotheses

- Null, H_0 (***difference in means is 0***)

  $\mu_1 - \mu_2 = 0$

- Alternative, H_a (Non-Directional)

  $\mu_1 - \mu_2 \neq 0$

Step 2: Set Rejection Criterion

- Significance Level: a = 0.05
- Critical value (*t*-distribution, *df* = n -1 = 9)
  - Two-tailed (non-directional)
  - t_{cv} = 2.262
  - Reject H_0 if t_{stat} >= 2.262

Step 3: Compute Test Statistics

Std Error: $s_{M_d} = \frac{s_d}{\sqrt{n}} = \frac{3.08}{\sqrt{10}} = 0.98$

Test statistics, $t = \frac{M_d - 0}{s_{M_d}} = \frac{-1.2}{0.98} = -1.22$

Step 4: Confidence Interval

- CI = Statistics +/- Critical Value (Standard Error)
- Mean of Difference, M_D = -1.2
- t_{cv} = 2.262 (two-tailed, *df* = 9 and a = 0.05)

- CI_{95} = -1.2 +/- 2.262(0.98) = -3.42 **to** 1.02

Step 5: Effect Size

- ES = Mean Difference / Standard deviation = $(M_1 - M_2)/s$
- Previously, S_d = 3.08 (Standard deviation of difference)

- ES = (-1.2 - 0)/3.08 = -0.39; So absolute *d* = **0.39**

- **Conclusion**: Small effect
  - (between 0.2 and 0.6: Small to Medium)

Step 6: Decision

- **<u>Do not</u>** reject H_0:
  - 1. $t_{stat} < t_{cv}$ or 1.23 < *2.262*
  - *2. Hypothesized population mean difference of 0 is within* CI_{95}
    - CI_{95}: *-3.42 to 1.02*
  - 3. ES = 0.38 is small to medium

- **Conclusion**: There is no reason to believe that cars with additives performance (by MPG) is significantly different from cars without additives

SPSS Outputs 1

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Words	39.2000	10	5.61348	1.77514
	No_Additives	40.4000	10	3.74759	1.18509

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Words & No_Additives	10	.857	.002

Correlation: Both samples are correlated, since p-value = **0.002** < **0.05**

SPSS Output 2

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	-1.20000	3.08401	.97525	-3.40617	1.00617	-1.230	9	.250

***t*-Test: <u>Do not</u>** reject null hypothesis – mean of difference is 0, since:

1. t_{test} = **1.23** < t_{cv} = **2.262** (two-tailed, *df* = 9, a = 0.05)

2. *p*-value = **0.250** > **0.05** and **3.** CI_{95} do contain **0**