Hypothesis Testing Practicals

10/2/2022

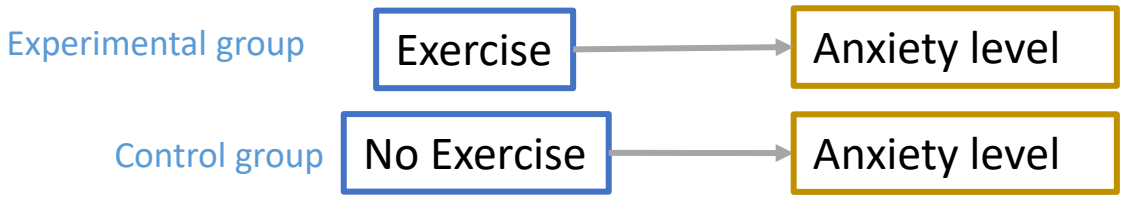
Spring 2022

DV: Anxiety level

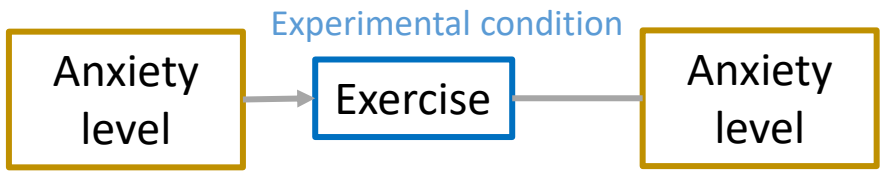
IV: Exercise

Do people who exercise have lower levels of anxiety?

Does exercise lower anxiety?

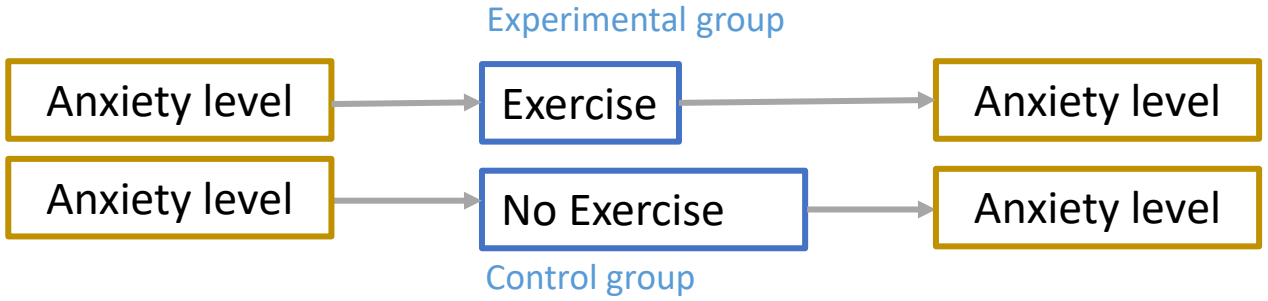


Between groups
(this does not allow you to measure change)



Within group/Repeated measures
(crossover design)

- Participant fatigue
- Longer experimental duration
- Carry over effects

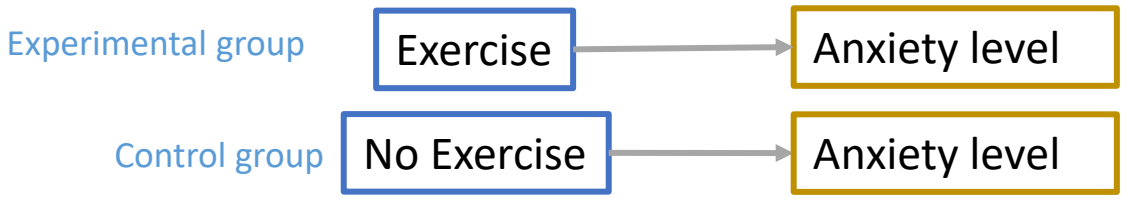


Mixed design
Between groups & Within groups

DV: Anxiety level

IV: Exercise

People who exercise have lower levels of anxiety



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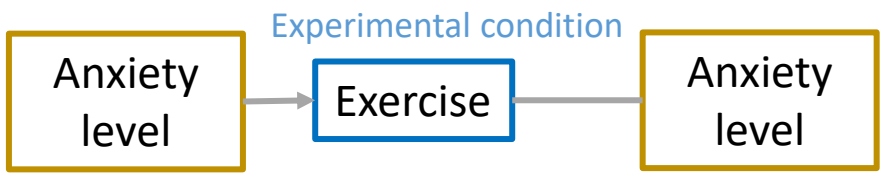

Within group/Repeated measures
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- Participant fatigue
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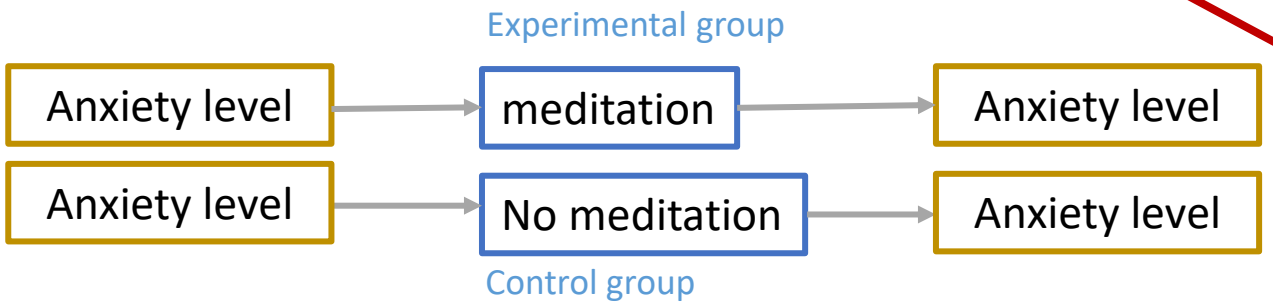
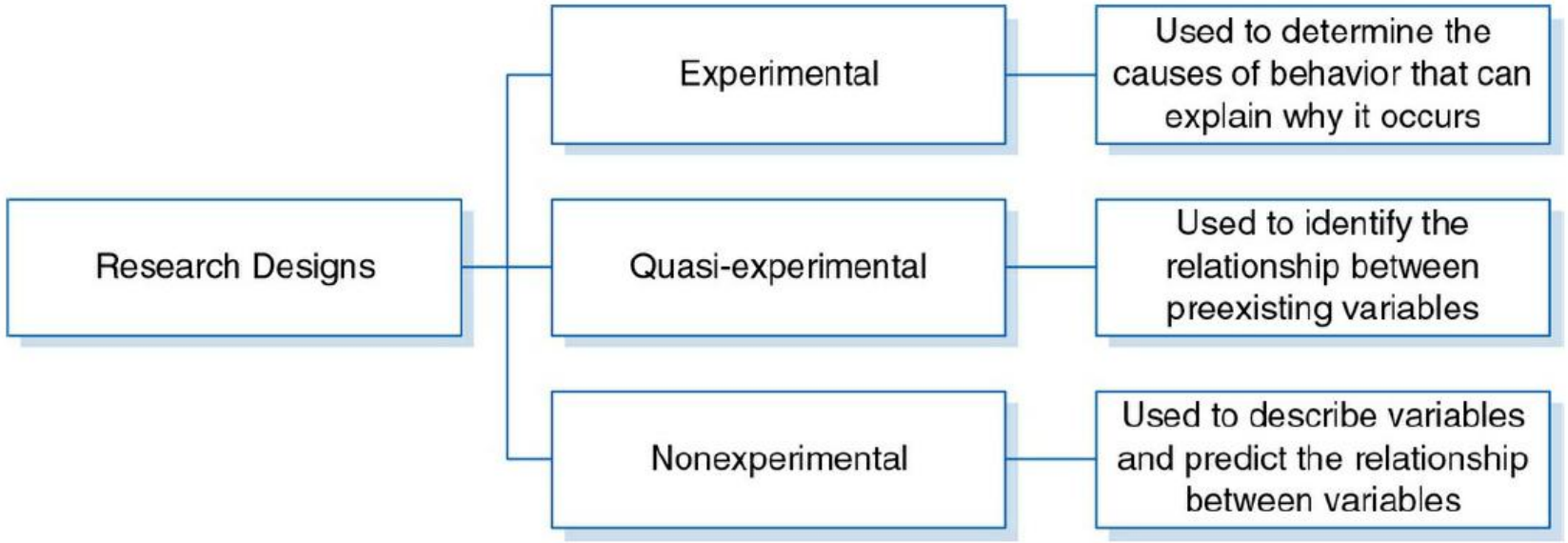
Exercise lowers anxiety



Mixed design
Between groups & Within groups

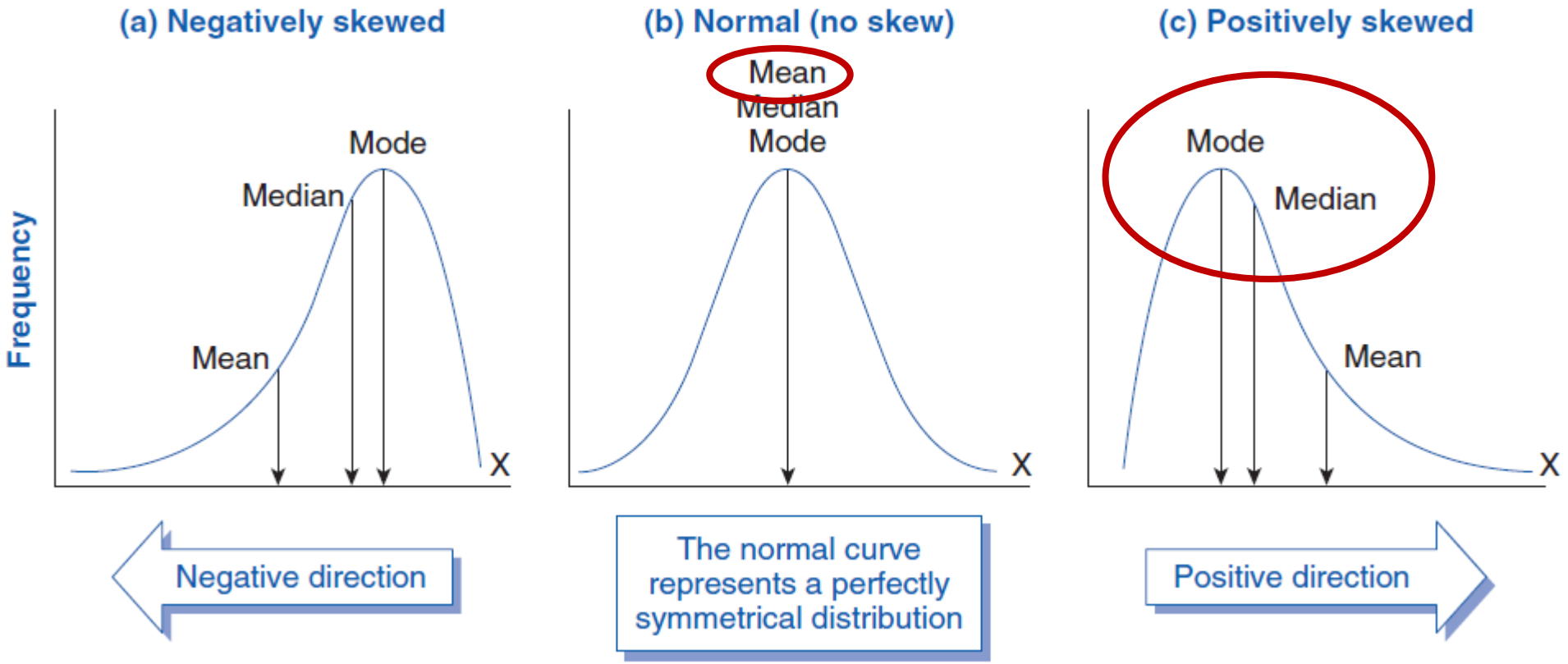


- Exercise lowers anxiety
- People who exercise have lower levels of anxiety
- A class teacher observes and records the behaviour of her students when they exercise and when they don’t exercise

Anxiety levels

	Exercise	No -Exerci
	20	24
	23	35
	25	41
	30	21
	35	38
	29	23
	37	37
	24	44
	29	32
	31	33
	26	34
	28	42
Mean	28.08333	33.66667
SD	4.680782	7.261007

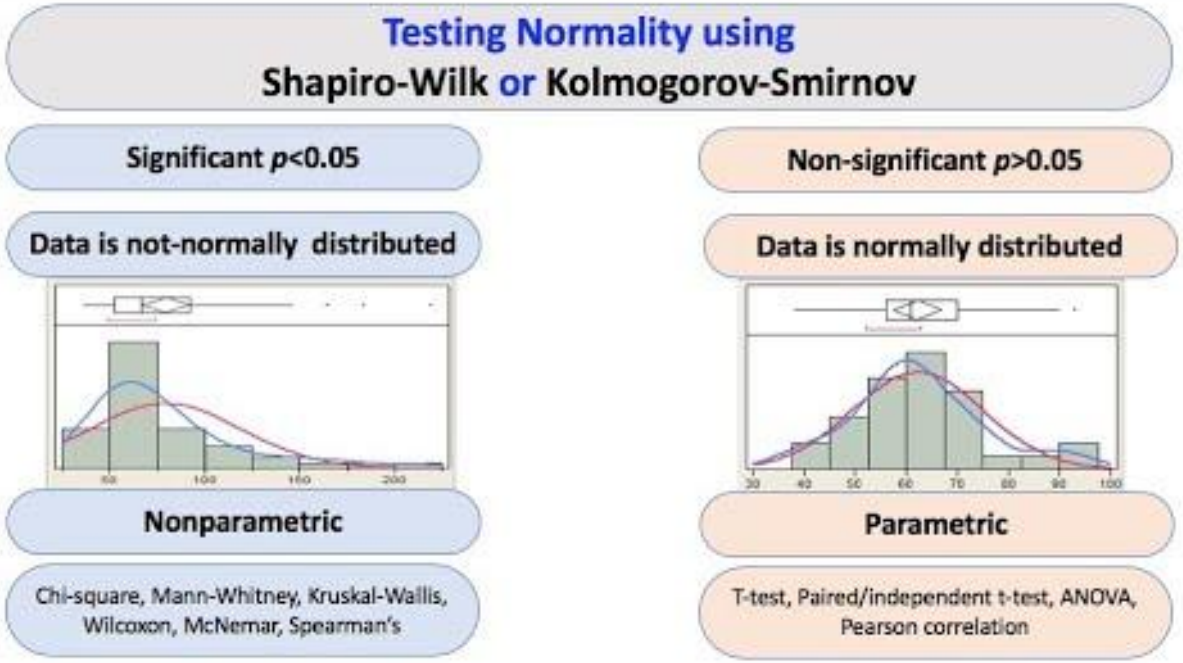
Normality?



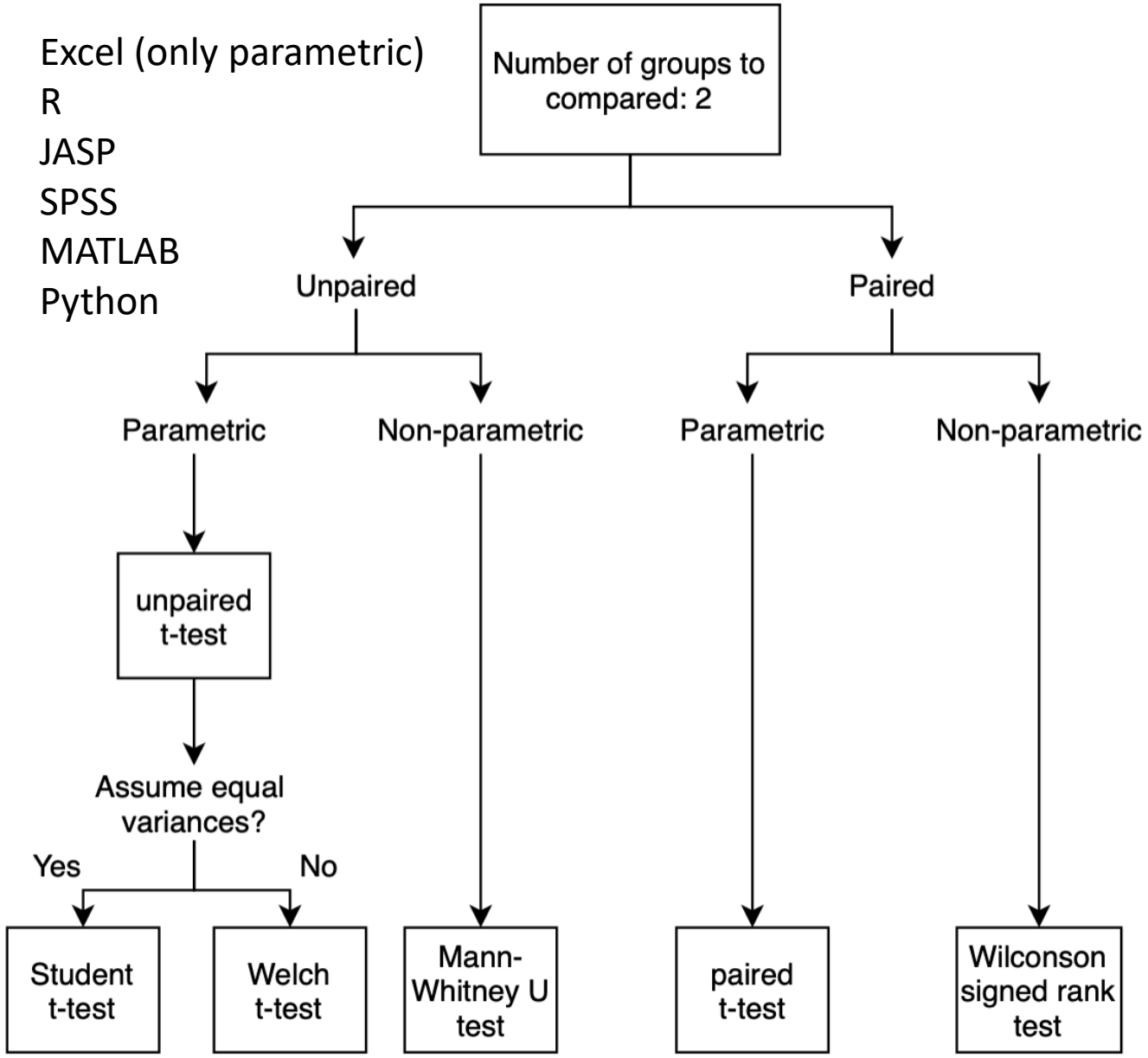
Kolmogorov–Smirnov test (n>=50)
OR
Shapiro–Wilk test (n<50)

The null hypothesis for normality → data is normally distributed

Parametric vs non-parametric



Excel (only parametric)
R
JASP
SPSS
MATLAB
Python



Independent Sample t test

T-Test Example

People who exercise have lower levels of anxiety

Anxiety levels

	Exercise	No -Exerci
	20	24
	23	35
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	37	37
	24	44
	29	32
	31	33
	26	34
	28	42
Mean	28.08333	33.66667
SD	4.680782	7.261007

	Exercise	*No -Exercise*
Mean	28.08333333	33.66666667
Variance	23.90151515	57.51515152
Observations	12	12
Pooled Variance	40.70833333	
Hypothesized Mean Diff	0	
df	22	
t Stat	-2.143519905	
P(T<=t) one-tail	0.021690748	
t Critical one-tail	1.717144374	
P(T<=t) two-tail	0.043381495	
t Critical two-tail	2.073873068	

t-value

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$\bar{x}_1$: Mean value of the first group
$\bar{x}_2$: Mean value of the second group
n_1 : Size of the first group
n_2 : Size of the second group
s_1 : Standard deviation of the first group
s_2 : Standard deviation of the second group

$$\text{Cohen's Effect size} = \frac{(\text{Mean}_{\text{treatment}} - \text{Mean}_{\text{control}})}{\text{Standard deviation}_{\text{pooled}}}$$

Cohen's d = (33.66 - 28.083) / 6.107782 = **0.913097**

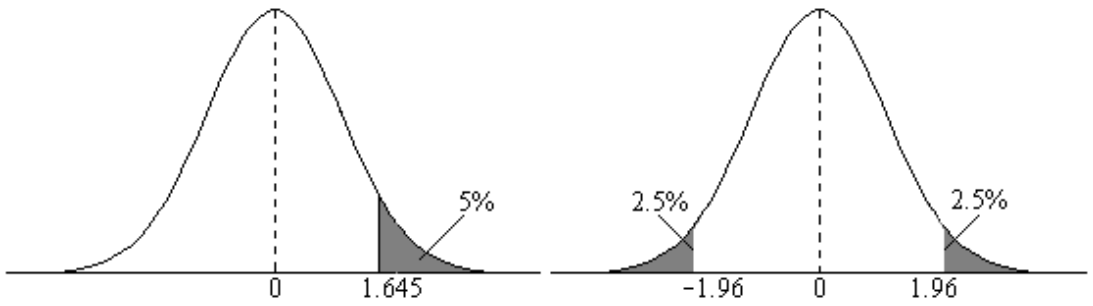
Cohen's d effect size interpretation

< 0.1 = trivial effect
0.1 - 0.3 = small effect
0.3 - 0.5 = moderate effect
> 0.5 = large difference effect

t(*df=22*) = -2.14, p=0.04, *d* = 0.9

Critical value α = 0.05

df= 22



(a) One-tailed test (b) Two-tailed test

Statistic	df	Explanation
ANOVA: Mean Sum of Squares Within (MSW)	N - k	N: total # of all data points k: # of groups
ANOVA: Mean Sum of Squares Between (MSB)	k - 1	
χ^2	n - 1	n: Sample Size
χ^2 test for Goodness of Fit	n - 1	k: # of categories
χ^2 test for Independence	(r – 1)(c – 1)	r: # of rows, c: #columns
χ^2 test for Variance	n - 1	n: Sample Size
F	$n_1 - 1$ and $n_2 - 1$	n_1 and n_2: Sizes of the 2 Samples
t	n - 1	n: Sample Size
1-Sample t-test, and Paired t-test	n - 1	
2 (Independent)-Sample t-test	$n_1 + n_2 - 2$	n_1 and n_2: Sizes of the 2 Samples

https://online.stat.psu.edu/stat414/lesson/26/26.4

Table T Critical Values of the *t* Distribution

df	One-Tail = .4 Two-Tail = .8	.25 .5	.1 .2	.05 .1	.025 .05	.01 .02	.005 .01	.0025 .005	.001 .002	.0005 .001
1	0.325	1.000	3.078	6.314	12.706	31.821	63.657	127.32	318.31	636.62
2	0.289	0.816	1.886	2.920	4.303	6.965	9.925	14.089	22.327	31.598
3	0.277	0.765	1.638	2.353	3.182	4.541	5.841	7.453	10.214	12.924
4	0.271	0.741	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.267	0.727	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.265	0.718	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.263	0.711	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.262	0.706	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.261	0.703	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.260	0.700	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.260	0.697	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.259	0.695	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.259	0.694	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.258	0.692	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.258	0.691	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.258	0.690	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.257	0.689	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.257	0.688	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.257	0.688	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.257	0.687	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.257	0.686	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.256	0.686	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.256	0.685	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	0.256	0.685	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.256	0.684	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.256	0.684	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.256	0.684	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.256	0.683	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.256	0.683	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.256	0.683	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	0.255	0.681	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
60	0.254	0.679	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
120	0.254	0.677	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	0.253	0.674	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

Source: From *Biometrika Tables for Statisticians*, Vol. 1, Third Edition, edited by E. S. Pearson and H. O. Hartley, 1966, p. 146. Reprinted by permission of the Biometrika Trustees.

Independent Samples T-Test

t-value

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$\bar{x}_1$: Mean value of the first group
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n_1 : Size of the first group
n_2 : Size of the second group
s_1 : Standard deviation of the first group
s_2 : Standard deviation of the second group

For equal sample size

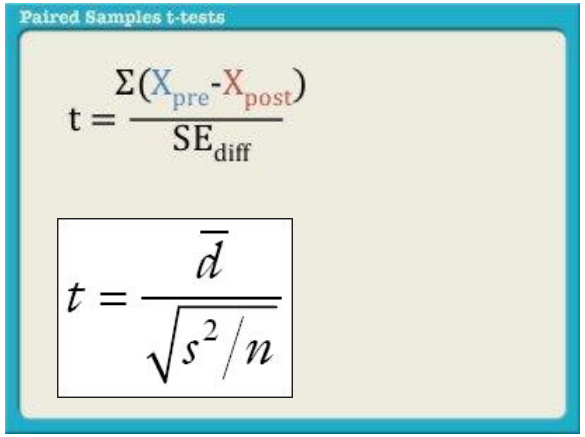
$df = (n1 + n2 - 2)$

For unequal sample size

$$\text{degrees of freedom, df} = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{1}{n_1 - 1}\left(\frac{s_1^2}{n_1}\right)^2 + \frac{1}{n_2 - 1}\left(\frac{s_2^2}{n_2}\right)^2}$$

Cohen's Effect size = $\frac{(\text{Mean}_{\text{treatment}} - \text{Mean}_{\text{control}})}{\text{Standard deviation}_{\text{pooled}}}$

Paired Samples T-Test



Independent Samples T-Test

t-value

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$\bar{x}_1$: Mean value of the first group
$\bar{x}_2$: Mean value of the second group
n_1 : Size of the first group
n_2 : Size of the second group
s_1 : Standard deviation of the first group
s_2 : Standard deviation of the second group

Cohen's Effect size = $\frac{\text{Mean}_{\text{difference}}}{\text{SD}_{\text{difference}}}$

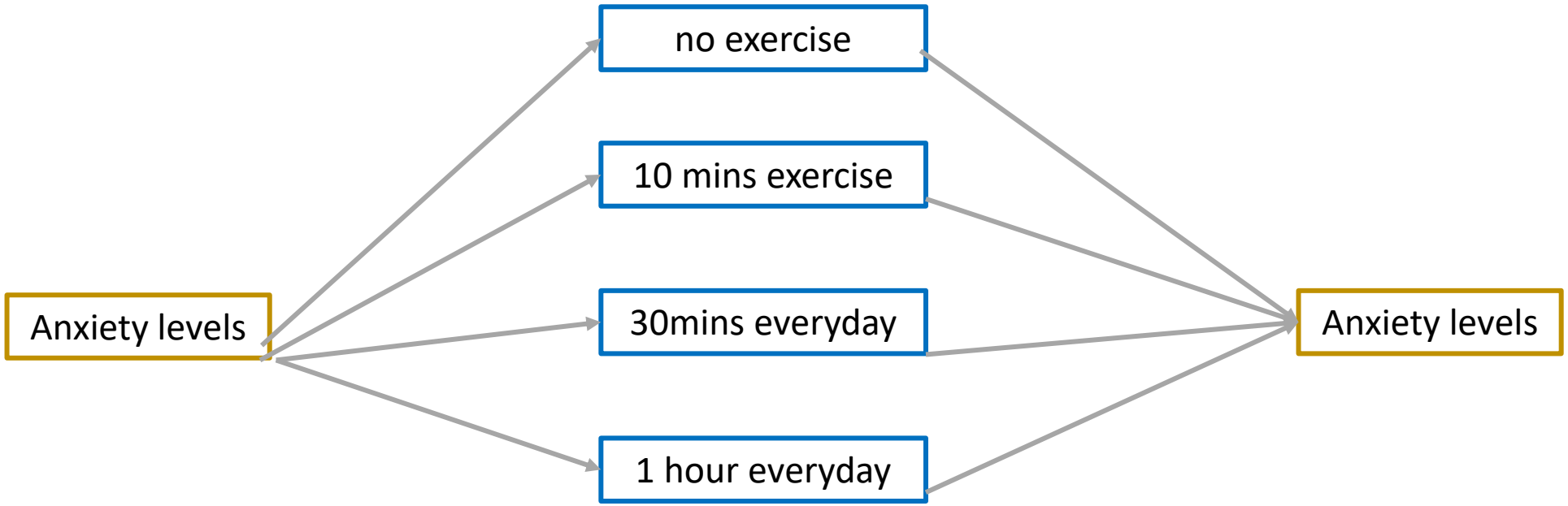
t-Test: Paired Two Sample for Means

	Variable 1	*Variable 2*
Mean	28.0833333	33.6666667
Variance	23.9015152	57.5151515
Observations	12	12
Pearson Corr	0.06701871	
Hypothesized	0	
df	11	
t Stat	-2.2120964	
P(T<=t) one-t	0.02451926	
t Critical one	1.79588482	
P(T<=t) two-t	0.04903853	
t Critical two	2.20098516	

DV: Anxiety level

IV: Exercise

IV – 4 levels



Factor = Independent variable

2 Independent Variables - 2 levels each

Exercise – exercise vs control

Time of Day – morning vs evening

Two factorial design

Exercise-morning	Control-morning
Exercise-evening	Control-evening

2x2 factorial design

2 Independent Variables – different levels

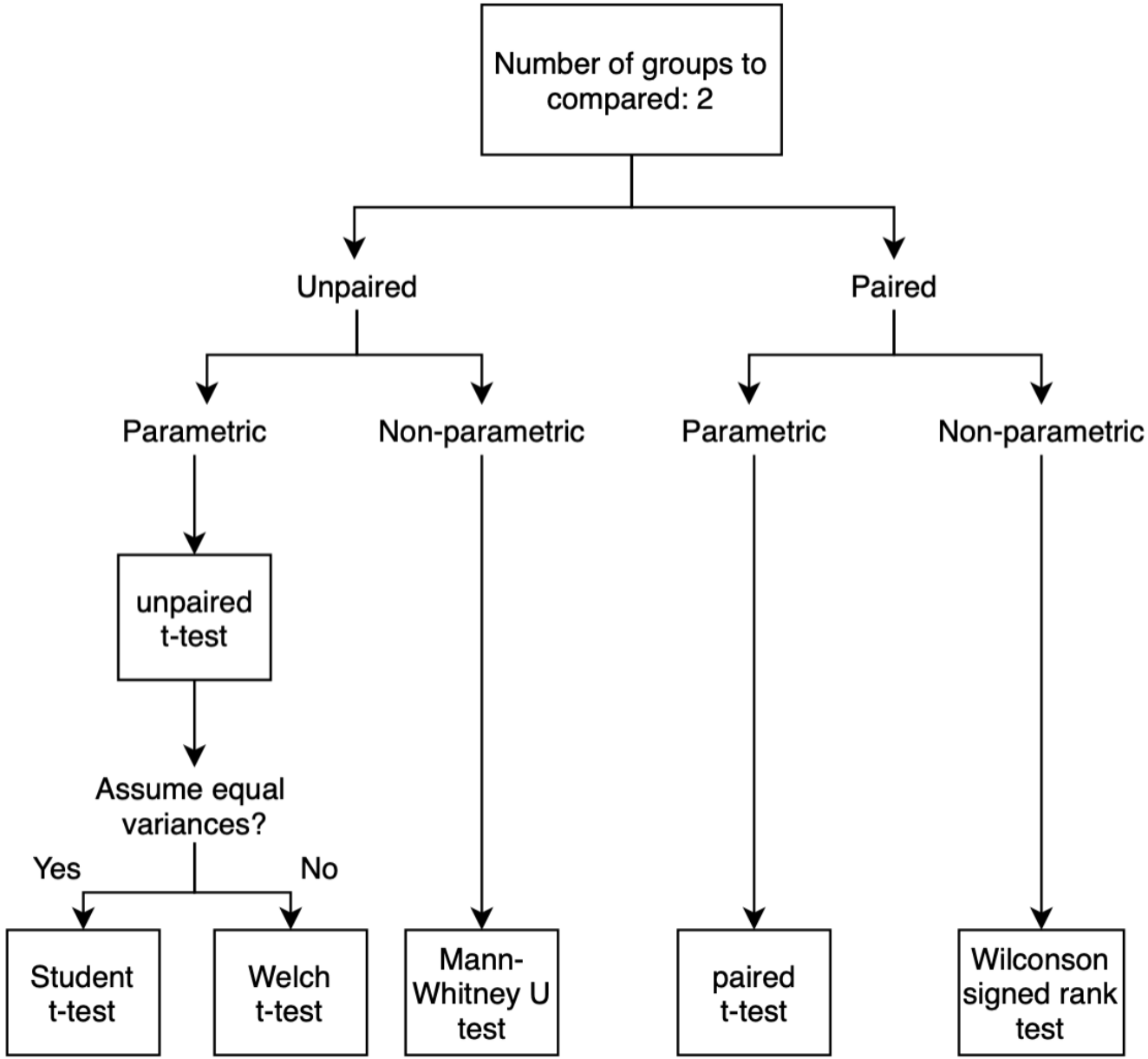
Exercise – 30mins, 1 hour, 2 hours

Time of Day – morning vs evening

Two factorial design

30 mins-morning	1 hr-morning	2 hrs - morning
30 mins-evening	1 hr-evening	2 hrs - evening

3x2 factorial design



Independent Sample t test