The T-Test

- Independent Sample T-Test
- Paired Sample T-Test
- One Sample T-Test
- Test of Significance

The One-Way ANOVA

- Post Hoc Comparisons
- Contrasts

Descriptive Statistics

What is a T-Test

T-Test is a procedure used for comparing Sample Means to see if there is sufficient evidence to infer that the means of the corresponding population distributions also differ. The important things are;

1. Two (t-test always compare two different means)

2. Some variable of interest

Ref: Statistics- A first course by John E Freund and Benjamin M.Perler, 7th Edition

SPSS PROVIDES THREE DIFFERENT TYPES OF T-TESTS

- INDEPENDENT SAMPLE T-TEST
- PAIRED SAMPLE T-TEST
- ONE SAMPLE T-TEST

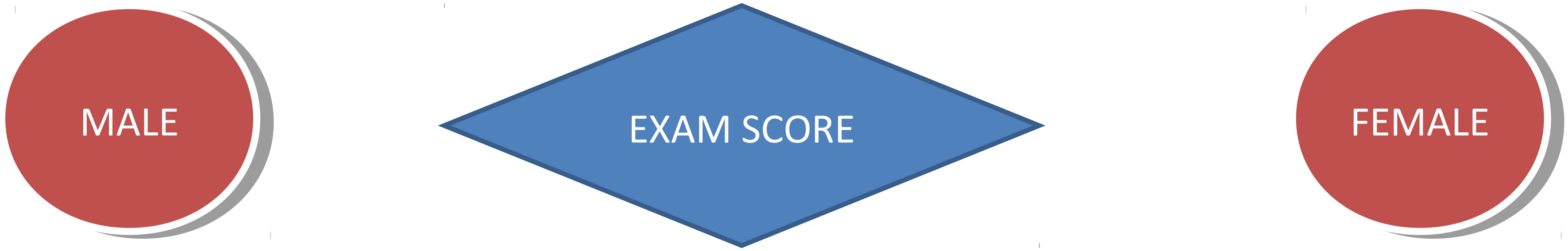
SPSS PRODUCES TWO-TAILED SIGNIFICANCE VALUE BY DEFAULT

- ONE TAIL TESTS
- TWO TAIL TESTS

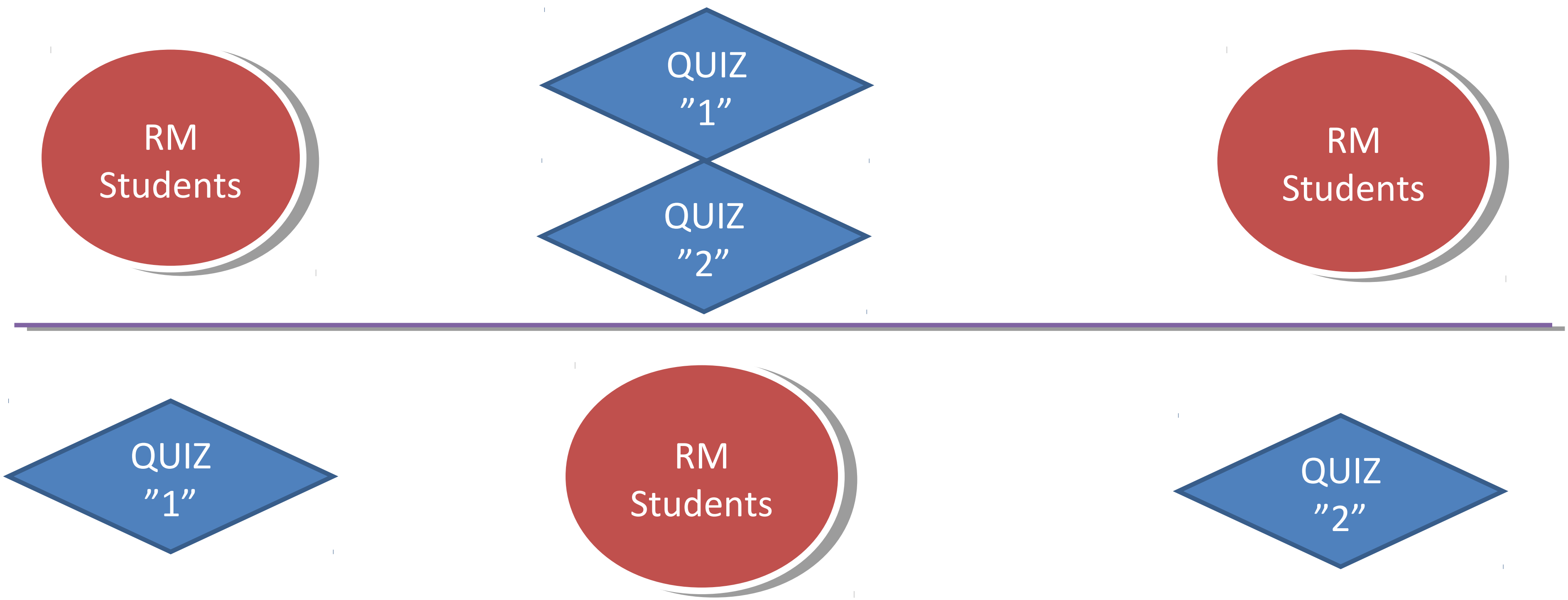
Difference Between Independent Sample T-Test and Paired Sample T-Test

Independent Sample T-Test	Paired Sample T-Test
• The two samples share some variable of interest in common, but there is no overlap between membership of two groups. • Compare the running speeds of horses and zebra would be an independent design as there is no sensible way to pair off each horse with each zebra.	• Usually based on the group of individuals who experience both conditions of the variable of interest. • Also called a Repeated Measure Design or a Paired Design. • Compare the running speed of horses for a week of eating one type of feed with the ***same*** horses for a week on a different type of feed would be a paired design as you can pair off measurements from the same horse

Independent Sample T-Test

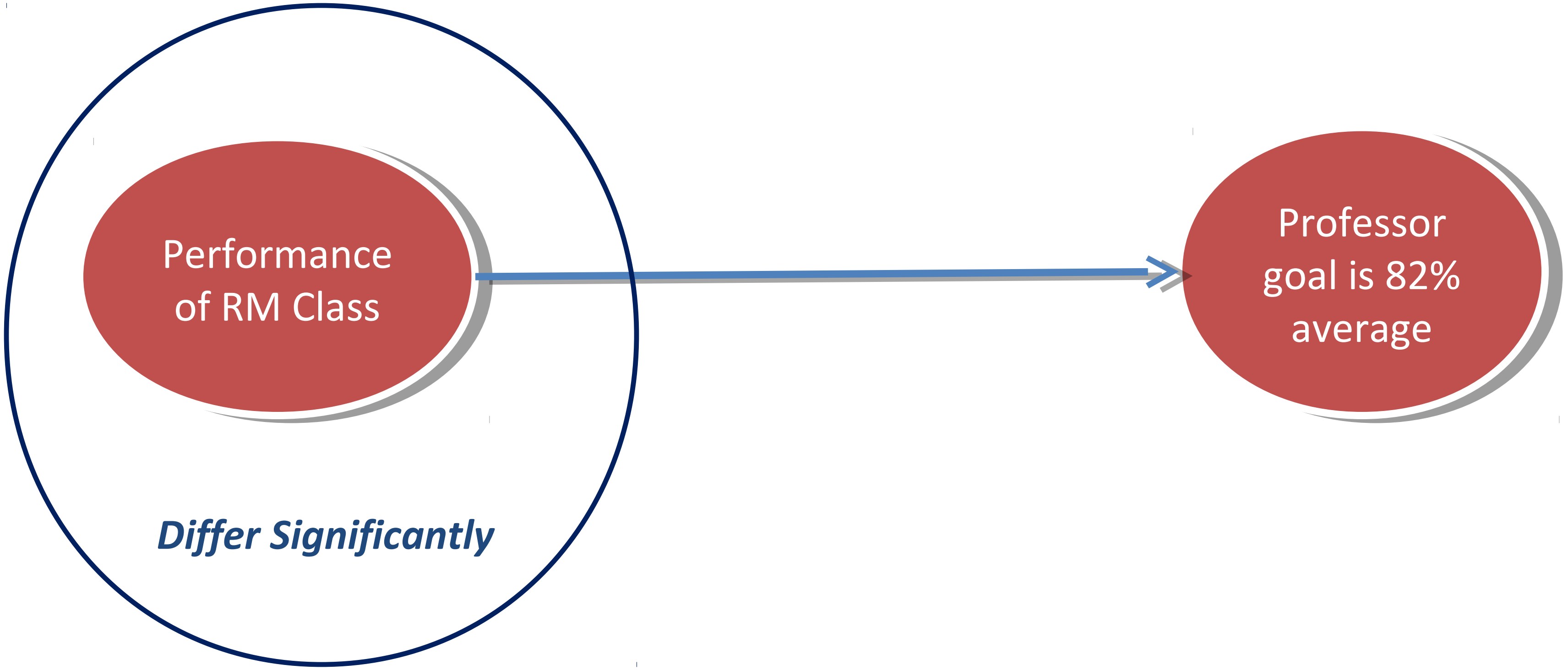


Paired Sample T-Test

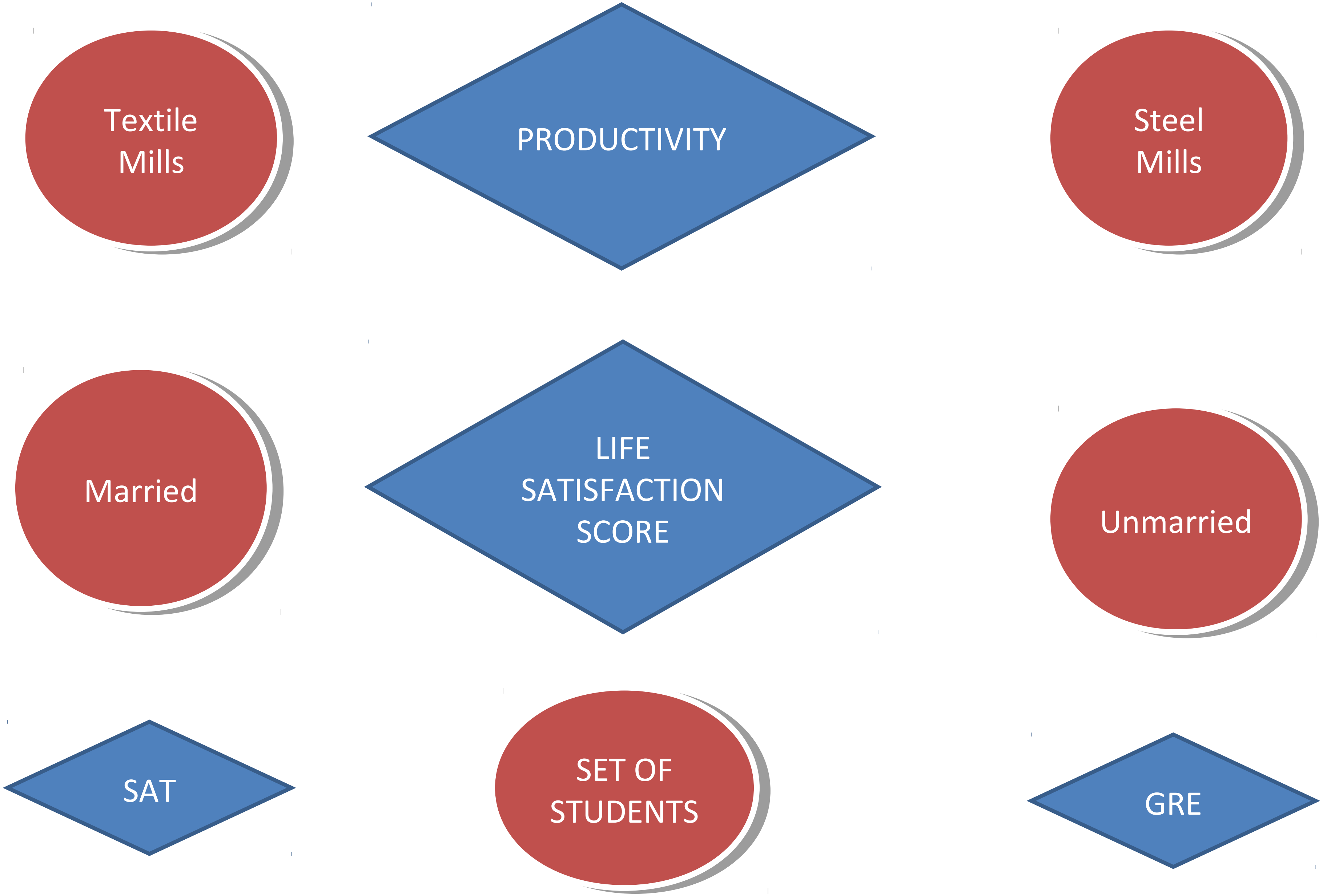


One Sample T-Test

It is designed to test whether the mean of a distribution differs significantly from some present value e.g.



Can You identify a T-Test



Independent Sample T-Test

Independent Sampl

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
total	Equal variances assumed	2.019	.158	1.224	103	.224
	Equal variances not assumed			1.169	72.421	.246

A Typical T-Table

α (1 tail)	0.05	0.025	0.01	0.005	0.0025	0.001	0.0005
α (2 tail)	0.1	0.05	0.02	0.01	0.005	0.002	0.001
df							
1	6.3138	12.7065	31.8193	63.6551	127.3447	318.4930	636.0450
2	2.9200	4.3026	6.9646	9.9247	14.0887	22.3276	31.5989
103	1.6598	1.9833	2.3631	2.6244	2.8687	3.1712	3.3875

Test of Significance

Test of Significance can be one-tailed or two tailed test;

Two tailed test examines whether the mean of one distribution differs significantly from the mean of other distribution. (Regardless of the direction +ve or –ve)

The one tailed test measures only whether the second distribution differs in a particular direction from the first.

One Tailed OR Two Tailed

If you have stated your experimental hypothesis with care, it will tell you which type of effect you are looking for.

For example, the hypothesis that "*Coffee improves memory*" is ________tailed test.

The hypothesis, "*Men weigh a different amount from women*" suggests a __________tailed test.

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*".

Ref: http://www.socialresearchmethods.net/kb/stat_t.php

Independent Sample T-Test

Group Statistics

	gender	N	Mean	Std. Deviation	Std. Error Mean
total	Female	64	102.03	13.896	1.737
	Male	41	98.29	17.196	2.686

How close a sample mean might be to the mean of the population from which the sample came.

These are standard errors of each mean separately;
$SE_M = SD/\sqrt{N}$

Ref: Student Edition Statistics (Tutorial and Softare) for Behavioral Sciences by Joseph D.Allen and David .J. Pittenger, 2nd Edition

Independent Sample T-Test

Independent Sampl

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P-Value

Levene's Test determines whether the variability from two groups is significantly different. If this were significant, one might consider using the t-test for un-equal variances

The "t", "df" and "Sig" columns provide the results of the statistical significance test. First the 't' provides standardized statistic for the mean difference;

$$t_{observed} = M_1 - M_2 \div SED$$

The t-statistic follows a non-normal (studentized or t) distribution that depends on degrees of freedom. Here

The degrees of freedom (df) of an

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Ref: SPSS for psychologists by Nicola Brace, Richard Kemp and Rosemary Snelgar

Independent Sample T-Test

So far we have learned the following things about a t-test;

1**.** The t-test produces a single value, *t*, which grows larger as the difference between the means of two samples grows larger;
2. *t* does not cover a fixed range such as 0 to 1 like probabilities do;
3. You can convert a t-value into a probability, called a p-value;
4. The p-value is always between 0 and 1 and it tells you the probability of the difference in your data being due to sampling error;
5*.* The p-value should be lower than a chosen significance level (0.05 for example) before you can reject your null hypothesis.

*This value is called the **critical value**. The final thing to do is compare this value with your value of t;*

If your t-value is greater than or equal to this value, then t is significant and you have found a difference

If your t-value is less than this value, then t is not significant.

Independent Sample T-Test

t-test for Equality of Means			
		95% Confidence Interval of the Difference	
Mean Difference	Std. Error Difference	Lower	Upper
3.739	3.053	-2.317	9.794
3.739	3.198	-2.637	10.114

The standard error of the difference is the function of two groups individual standard errors;

This section provides a confidence interval around the 'Mean Difference". Calculation requires the appropriate critical value.

The 'Mean Difference' is the

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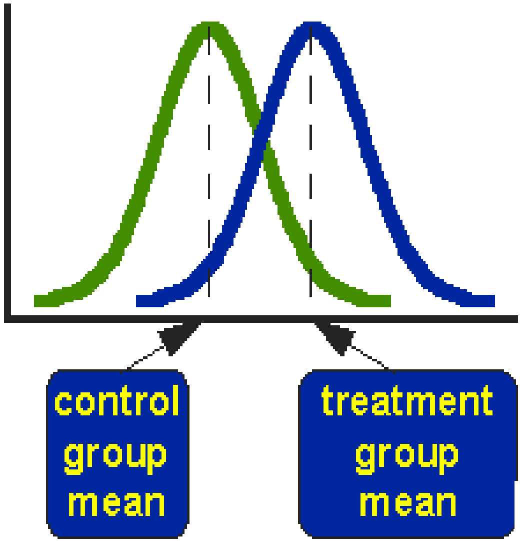
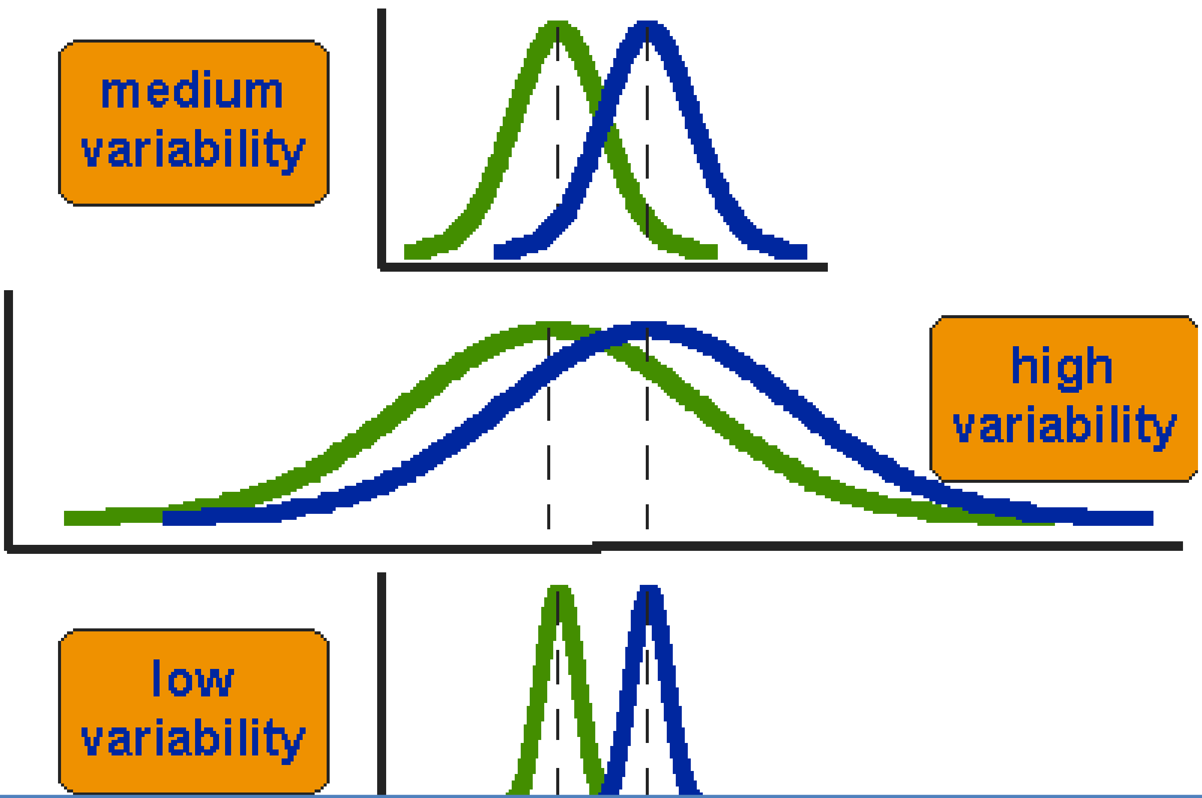
T-Test


control group mean
treatment group mean

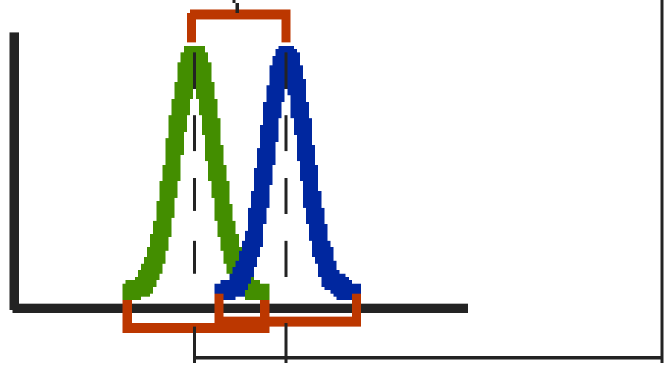

medium variability
high variability
low variability

T-Test

$$\frac{\text{signal}}{\text{noise}} = \frac{\text{difference between group means}}{\text{variability of groups}}$$

$$= \frac{\bar{X}_T - \bar{X}_C}{SE(\bar{X}_T - \bar{X}_C)}$$

$$= \text{t-value}$$



Ref: http://www.socialresearchmethods.net/kb/stat_t.php

CASE OF EQUAL VARINACES ASSUMED	CASE OF EQUAL VARINACES NOT ASSUMED
$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$	$$t = \frac{\bar{X}_T - \bar{X}_C}{\sqrt{\frac{var_T}{n_T} + \frac{var_C}{n_C}}}$$
n1+n2-2	$d.f. = (s_1^2/n_1 + s_2^2/n_2) \div (((s_1^2/n_1)^2 \div (n_1\text{-}1)) + ((s_2^2/n_2)^2 \div (n_2\text{-}1)))$
Standard Error of the Difference $\text{sqrt}(s^2(1/n_1 + 1/n_2))$ $s^2 = ((n_1 - 1)s_1^2 + (n_2 - 1)s_2^2)/ (n_1 + n_2 - 2)$	Standard Error of the Difference $\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$

Paired Sample T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	quiz1	7.47	105	2.481	.242
	quiz2	7.98	105	1.623	.158

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	quiz1 & quiz2	105	.673	.000

Though the statistic is not shown, t provides the standardized statistic for testing whether the correlation differs from zero;

$$\sqrt{(1-r2)}$$

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Ref: SPSS for psychologists by Nicola Brace, Richard Kemp and Rosemary Snelgar

Paired Sample T-Test

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	quiz1 - quiz2	-.514	1.835	.179	-.869	-.159	-2.872	104	.005

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One Sample T-Test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
percent	105	80.34	12.135	1.184

One-Sample Test

	Test Value = 85					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
percent	-3.932	104	.000	-4.657	-7.01	-2.31

The Mean Difference is the difference

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ONE WAY ANALYSIS OF VARIANCE (ONE WAY ANOVA)

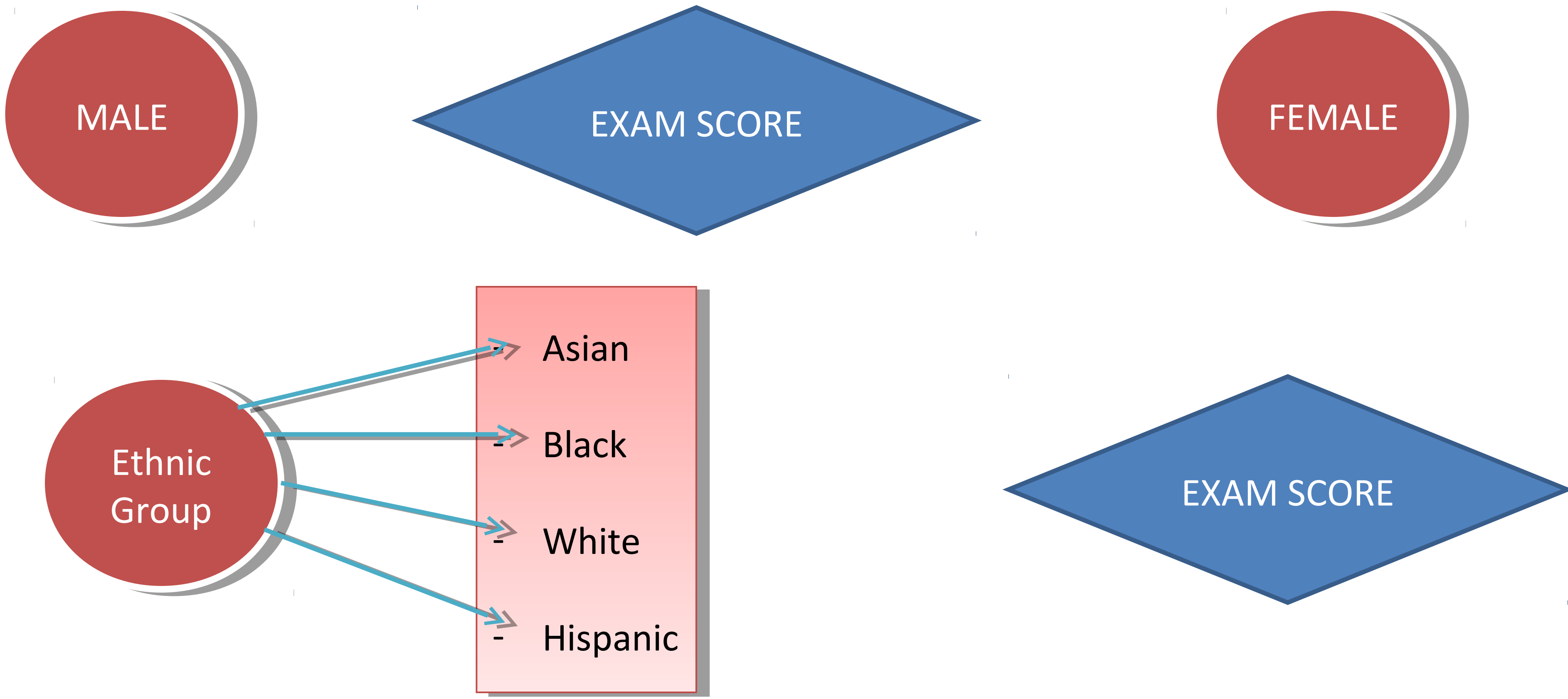
ANOVA

- Analysis of variance is a procedure used for comparing sample means to see if there is sufficient evidence to infer that the means of the corresponding population distributions also differ.

- Where t-test compare only two distributions, analysis of variance is able to compare many.

- What does the one-way part mean? It is one dependent variable (always continuous) and exactly one independent variable (always categorical). A single independent variable can have many levels

ANOVA



One-way ANOVA will generate a significance value indicating whether there are significant differences within the comparisons being made. This significance value does not indicate where the difference is or what the differences are; but a 'Test' can identify which groups differ significantly from each other.

One Way ANOVA

quiz4

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Asian	20	8.35	1.531	.342	7.63	9.07	6	10
Black	24	7.75	2.132	.435	6.85	8.65	4	10
White	45	8.04	2.256	.336	7.37	8.72	2	10
Hispanic	11	6.27	3.319	1.001	4.04	8.50	2	10
Total	100	7.84	2.286	.229	7.39	8.29	2	10

Test of Homogeneity of Variances

quiz4

Levene Statistic	df1	df2	Sig.
5.517	3	96	.002

Ref: SPSS Software

One Way ANOVA

$$SS_{BETWEEN} = \sum n(M_{GROUP} - M_{TOTAL})^2$$

ANOVA

quiz4

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.297	3	11.432	2.272	.085
Within Groups	483.143	96	5.033		
Total	517.440	99			

$$SS = SD^2 * df$$
$$SS_{Within} = SS_1 + SS_2 + SS_3$$

The sum of squares is the estimate of the variance multiplied by the degrees of freedom. It can be calculated in three ways;

-SST -SSW -SSB

The advantage of sum of squares is that it can deal

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One Way ANOVA

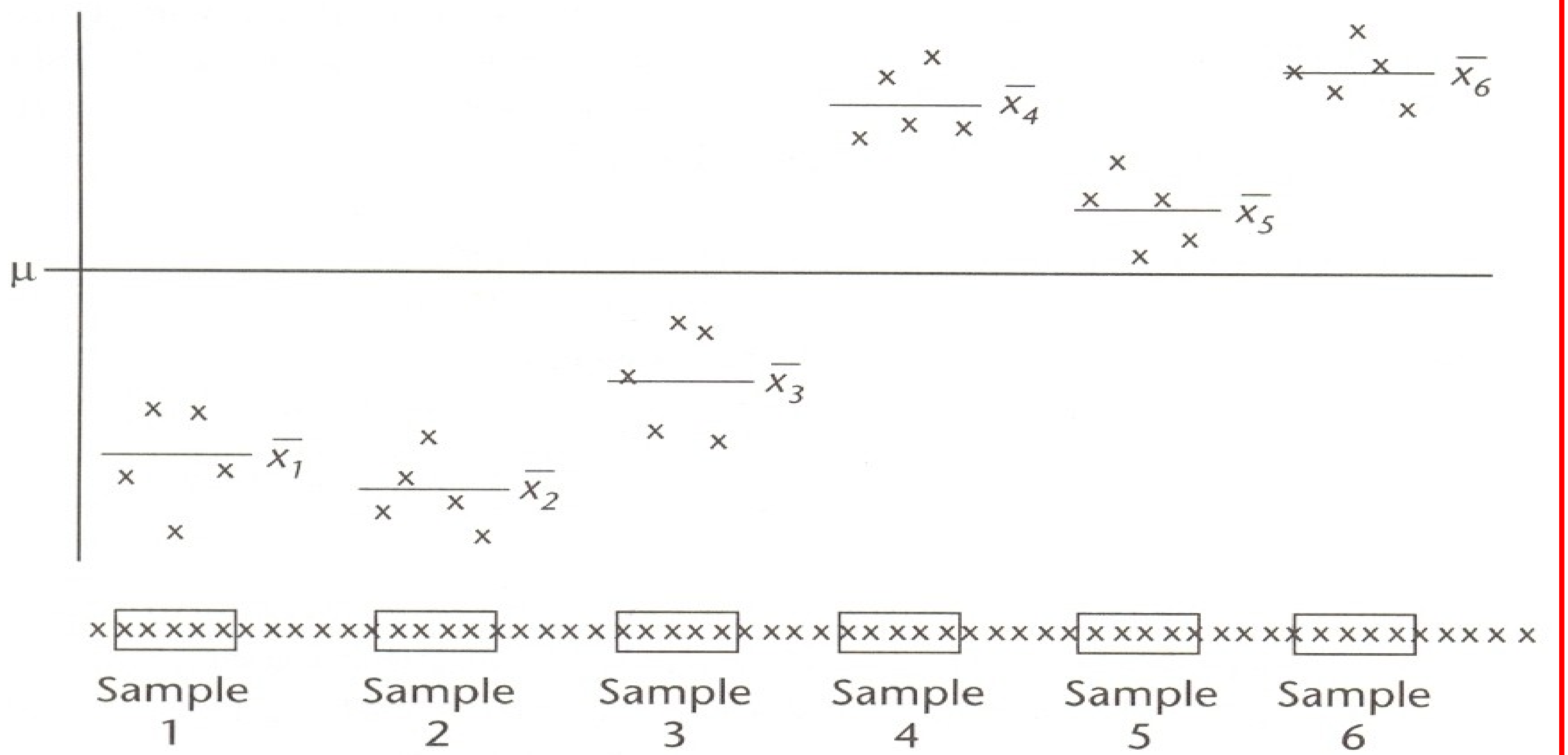

Figure F.6 *A visualisation of six samples, each sample has 5 observations. An illustration of different variation components. Within subgroup variation is the variation in each sample. Between subgroups variation is the variation between the samples, i.e. the variation in the mean values of the subgroups. The total variation is the total long range variation in the process. From Bergman and Klefsjö, 2003, 'Quality, from Customer Needs to Customer Satisfaction'.*

One Way ANOVA

ANOVA

quiz4

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.297	3	11.432	2.272	.085
Within Groups	483.143	96	5.033		
Total	517.440	99			

$MS = SS / df$

$F = MSB / MSW$

When "F" ratio is close to "1", the estimates will be said to be similar (no indication of detectable differences between subgroup means). When F-ratio is large, the estimates are dissimilar (indication of differences between subgroup means).

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One Way ANOVA – Post Hoc Tests

quiz4
LSD

(I) ethnicity	(J) ethnicity	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Asian	Black	.600	.679	.379	-.75	1.95
	White	.306	.603	.613	-.89	1.50
	Hispanic	2.077*	.842	.015	.41	3.75
Black	Asian	-.600	.679	.379	-1.95	.75
	White	-.294	.567	.605	-1.42	.83
	Hispanic	1.477	.817	.074	-.14	3.10
White	Asian	-.306	.603	.613	-1.50	.89
	Black	.294	.567	.605	-.83	1.42
	Hispanic	1.772*	.755	.021	.27	3.27
Hispanic	Asian	-2.077*	.842	.015	-3.75	-.41
	Black	-1.477	.817	.074	-3.10	.14
	White	-1.772*	.755	.021	-3.27	-.27

Ref: SPSS Software