Quantitative Business Research Methods – Day 3

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Causality and Experiments

Ordinary versus scientific meaning of causality

Ordinary meaning	Scientific meaning
X is the only cause of Y	X is only one of a number of possible causes of Y
X must always lead to Y	The occurrence of X makes the occurrence of Y more probable (X is a probabilistic cause of Y)
It is possible to prove that X is a cause of Y	We can never prove that X is a cause of Y. At best, we can infer that X is a cause of Y

Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Conditions for causality

- Concomitant variation is the extent to which a cause, X, and an effect, Y, occur together or vary together in the way predicted by the hypothesis under consideration.

- The time order of occurrence condition states that the causing event must occur either before or simultaneously with the effect; it cannot occur afterwards.

- The absence of other possible causal factors means that the factor or variable being investigated should be the only possible causal explanation.

Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Causality and experiments: Definitions and concepts

- **Independent variables** are variables or alternatives that are manipulated and whose effects are measured and compared, for example, price levels.
- **Test units** are individuals, organisations or other entities whose response to the independent variables or treatments is being examined, for example, consumers or stores.
- **Dependent variables** are the variables which measure the effect of the independent variables on the test units, for example, sales, profits and market shares.
- **Extraneous variables** are all variables other than the independent variables that affect the response of the test units, for example, store size, store location and competitive effort.

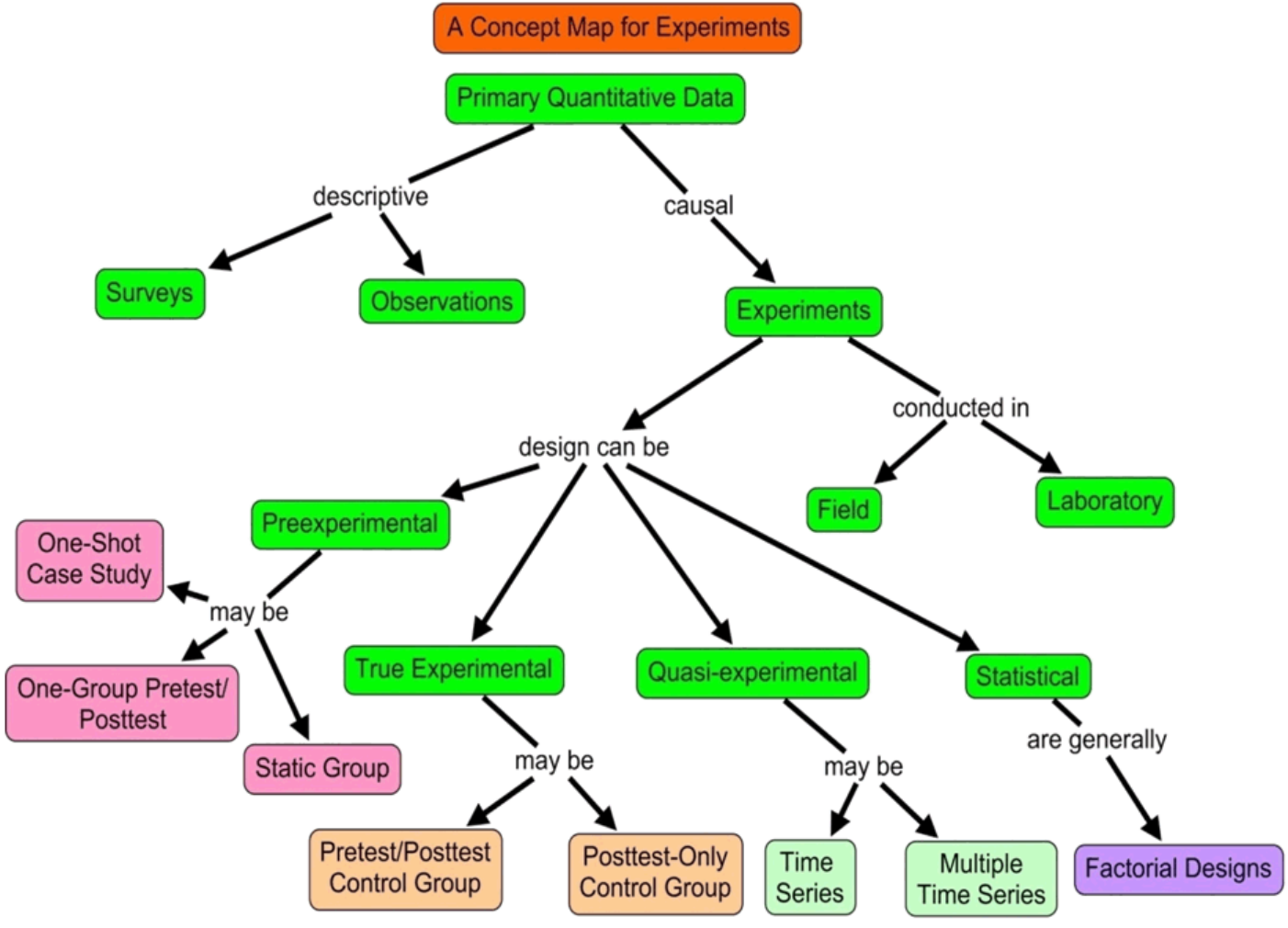
Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Validity in experimentation

- **Internal validity** refers to whether the manipulation of the independent variables or treatments actually caused the observed effects on the dependent variables. Control of extraneous variables is a necessary condition for establishing internal validity.

- **External validity** refers to whether the cause-and-effect relationships found in the experiment can be generalised. To what populations, settings, times, independent variables and dependent variables can the results be projected?

Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.



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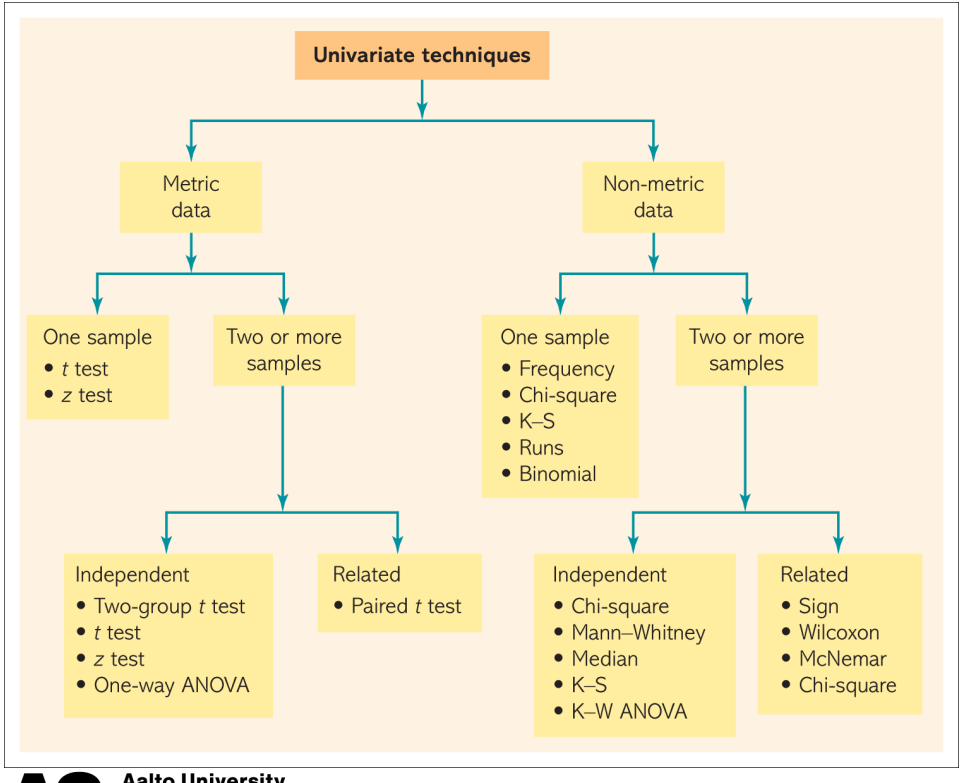
Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

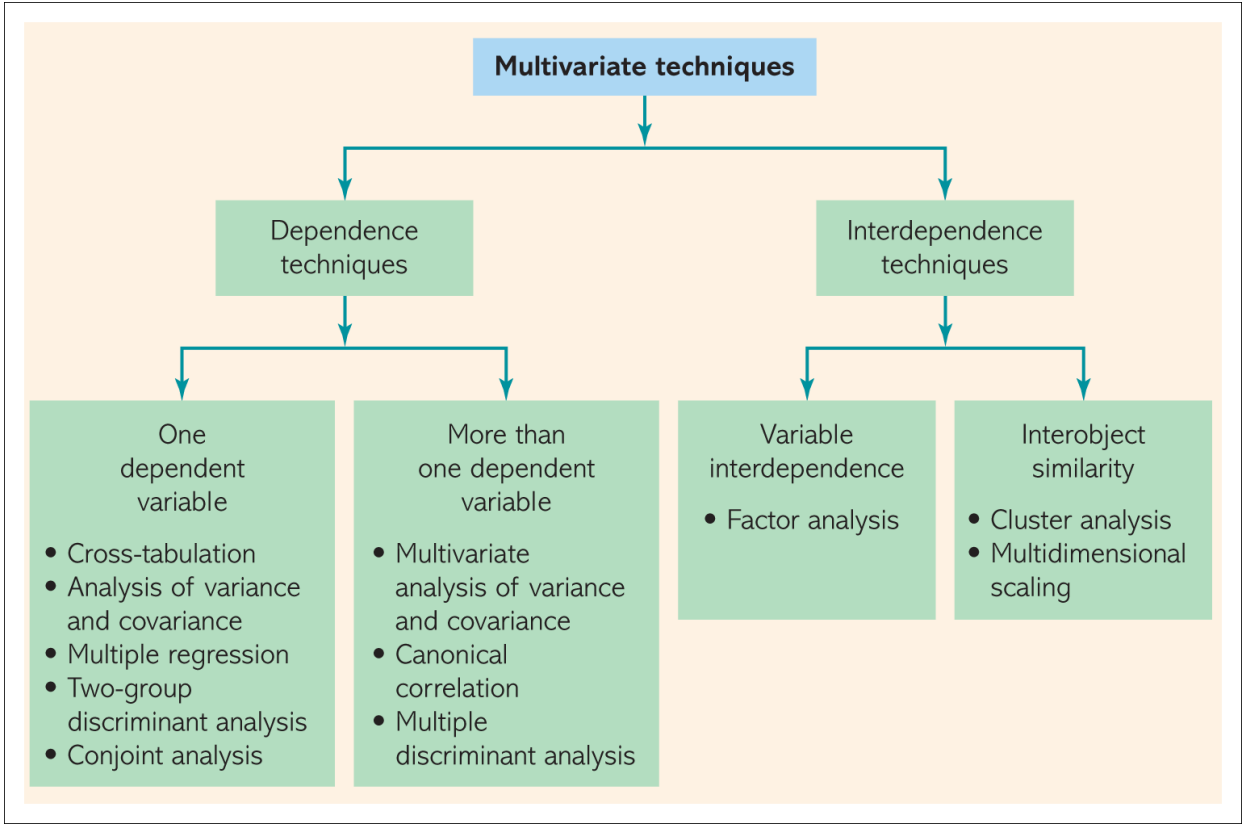
Univariate vs. Multivariate Techniques

Univariate techniques



Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Multivariate techniques



Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Basic Statistics

- The **mean**, or average value, is the most commonly used measure of central tendency. The mean, $\overline{X}$, is given by:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where

X_i = observed values of the variable X

n = number of observations (sample size).

- The **mode** is the value that occurs most frequently. It represents the highest peak of the distribution. The mode is a good measure of location when the variable is inherently categorical or has otherwise been grouped into categories.

Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Basic Statistics

- The **median** of a sample is the middle value when the data are arranged in ascending or descending order. If the number of data points is even, the median is usually estimated as the midpoint between the two middle values – by adding the two middle values and dividing their sum by 2. The median is the 50th percentile.

Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Basic Statistics

- The **variance** is the mean squared deviation from the mean. The variance can never be negative.
- The **standard deviation** is the square root of the variance.

$$s_x = \sqrt{\frac{\sum_{i\text{-}1}^{n} (X_i - \overline{X})^2}{n - 1}}$$

- The **coefficient of variation** is the ratio of the standard deviation to the mean expressed as a percentage, and it is a unitless measure of relative variability.

$$\text{CV} = \frac{s_x}{\overline{X}}$$

Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Hypothesis testing

- A null hypothesis is a statement of the status quo, one of no difference or no effect. If the null hypothesis is not rejected, no changes will be made.
- An alternative hypothesis is one in which some difference or effect is expected. Accepting the alternative hypothesis will lead to changes in opinions or actions.

Source: Nunan et al. (2020): Marketing Research - Applied Insight. Sixth Edition.

Data Analysis with SPSS Software

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Analysis with SPSS

- Most important analysis with SPSS:

1. Crosstabulation (tables with percentages) and Chi-square test
2. Comparing means of two groups and T-test
3. Comparing means of more than two groups and Analysis of Variance (ANOVA)

Chi-square test

Crosstabulation and Chi-square test

- Tests the probability that the table is not a result of randomness (instead there is statistical significance).
- Two conditions need to be met if we want to use chi-square:
  - 1. Max 20 percent of the expected frequencies can be < 5
  - 2. All expected frequencies must be > 1
  - SPSS shows these statistics when using the Chi-square test but does not tell you when the conditions are met.

Chi-square test: Example

- Here, two datasets (1996 and 2013) are compared. Null hypothesis is that there is equal distribution of companies from different industry sectors in both datasets.
- Chi-square is not significant (p=.20) so null hypothesis is accepted.

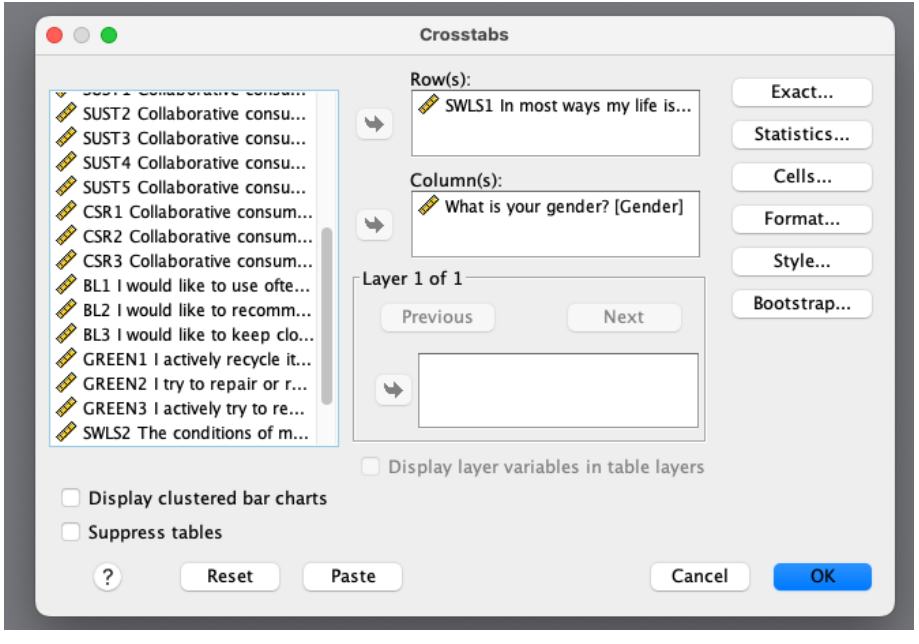
Table 1 Sample structure

Characteristics		1996	2013
Industry sectors	Consumer packaged goods	33 %	34 %
	Electrical equipment	30 %	24 %
	Mechanical machinery	37 %	42 %
	Goodness of fit with 1996 sample H_0: Equal distribution as 1996 sample		$\chi^2(2)=3.24$ ($p=.20$)

Source: Homburg, C., Vomberg, A., Enke, M. and Grimm, P.H. (2015), "The loss of the marketing department's influence: is it really happening? And why worry?", Journal of the Academy of Marketing Science, Vol. 43 No. 1, pp. 1–13.

Chi-square test with SPSS

- Analyze – Descriptive Statistics – Crosstabs
- Choose Chi-Square test in the statistics.



Chi-square test with SPSS

- If Sig. related to Chi-Square test is below 0.05 we conclude that the result is statistically significant (not result of randomness).

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	15.008[a]	6	.020
Likelihood Ratio	15.659	6	.016
Linear-by-Linear Association	.192	1	.661
N of Valid Cases	200		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.34.

The Chi-Square value is statistically significant.

The assumptions of the test are met!

T-test

Comparing means and t-test

- The t-test checks for differences between the means of two groups:
  - e.g. is there a statistically significant difference between the sales of product A and the sales of product B.
  - e.g. is there a statistically significant difference between the attitudes of men and women as measured by a survey item.

T-test: Example

Table 2 Influence of departments over specific issues: results of 1996 and 2013 (with t-tests comparing influence over time)

Decisions regarding	Marketing			Sales			R&D			Operations			Finance		
	1996	2013	Δ	1996	2013	Δ	1996	2013	Δ	1996	2013	Δ	1996	2013	Δ
Pricing	24	19	−5*	47	50	3	4	6	2	7	9	2	18	17	−1
New product development	31	24	−7**	26	30	4*	27	32	5*	8	8	0	8	6	−2
Strategic direction of the business unit	39	30	−9***	34	41	7**	8	11	3	5	6	1	13	12	−1
Major capital expenditures	14	11	−3*	14	16	2*	12	14	2	23	21	−2	37	38	1
Expansion into new geographic markets	36	21	−15***	49	61	12***	2	3	1	2	2	0	11	11	0
Choices of strategic business partners	27	18	−9***	53	57	4	6	10	4*	5	6	1	9	9	0
Design of customer service and support	29	26	−3	54	59	5	4	5	1	6	5	−1	6	6	0
Customer satisfaction improvement programs	42	45	3	41	45	4	5	3	−2*	5	3	−2*	6	5	−1
Distribution strategy	32	23	−9***	59	67	8**	2	2	0	3	4	1	5	4	−1
Advertising messages	62	70	8**	33	25	−8**	3	3	0	1	0	−1*	2	1	−1
Customer satisfaction measurement	54	56	2	37	37	0	3	1	−2*	3	3	0	3	3	0

*$p<.05$; **$p<.01$; ***$p<.001$

We present the decision areas in decreasing order of their importance for the success of the strategic business unit (assessed by our key informants). The number in each cell is the mean of the number of points given by the key informants to each department, using a constant-sum scale of 100. Sum may not add up to 100 due to rounding. Values for 2013 are adjusted by sales volume according to 1996. The "Δ-columns" display *t*-tests that were performed to compare the relative influence of each department between 1996 and 2013

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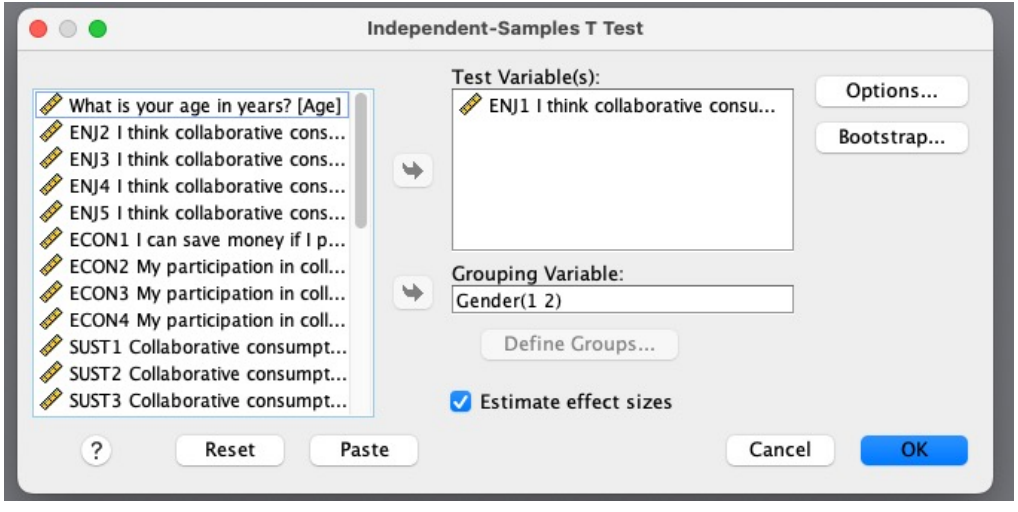
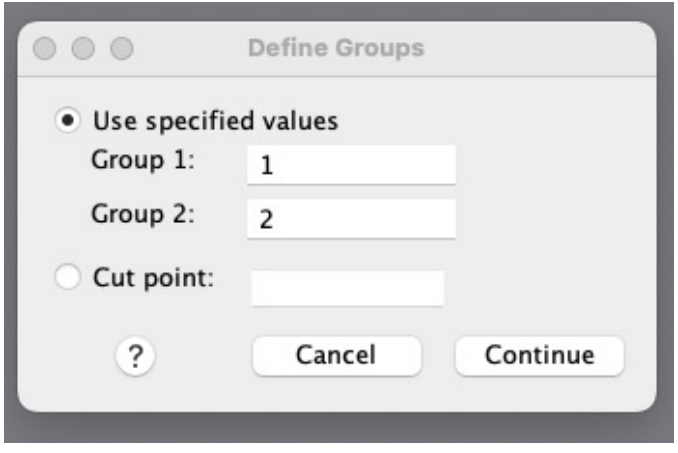
Source: Homburg, C., Vomberg, A., Enke, M. and Grimm, P.H. (2015), "The loss of the marketing department's influence: is it really happening? And why worry?", Journal of the Academy of Marketing Science, Vol. 43 No. 1, pp. 1–13.

T-test with SPSS

- Analyze – Compare means – Independent Samples T test





T-test with SPSS

- If p value of Levene's test is small ($p < .05$), the variances are not equal and we must use "equal variances not assumed" t-test. Here, we use "equal variances assumed" t-test. And the t-test result is not significant (no difference between opinions of males and females).

T-Test

Group Statistics

	What is your gender?	N	Mean	Std. Deviation	Std. Error Mean
ENJ1 I think collaborative consumption is enjoyable.	Male	89	5.3820	1.17266	.12430
	Female	111	5.1802	1.27349	.12087

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
ENJ1 I think collaborative consumption is enjoyable.	Equal variances assumed	.101	.750	1.154	198	.125	.250	.20184	.17497	-.14320	.54688
	Equal variances not assumed			1.164	194.198	.123	.246	.20184	.17338	-.14011	.54380

Analysis of Variance (ANOVA)

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Comparing means and ANOVA

- ANOVA tests for differences in the mean across groups
  - Allows (much) more complex hypothesis testing than t-test.
  - E.g. there can be more than two groups.

ANOVA: Example

Source: Jin, Z., Hewitt-Dundas, N. and Thompson, N.J. (2004), "Innovativeness and performance: evidence from manufacturing sectors", Journal of Strategic Marketing, Vol. 12 No. 4, pp. 255–266.

TABLE 5. Types of innovator and organisational performance: one-way ANOVA

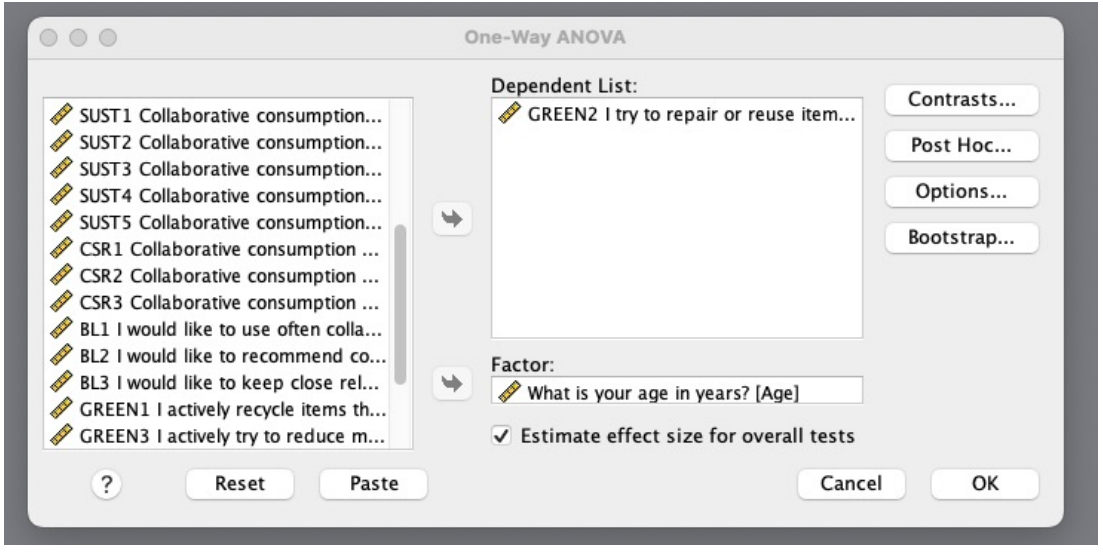
Cluster	Sales growth		Employment growth	
	Mean	Standard deviation	Mean	Standard deviation
Non-innovator (N = 249)	25.2	50.2	11.2	41.1
Creator (N = 127)	39.9	64.3	22.2	41.0
All-round innovator (N = 44)	74.31	108.7	44.7	68.8
Adopter (N = 111)	46.37	76.9	27.4	55.5
Total	37.11	67.2	19.8	47.9
F	14.0		14.7	
Significance	0.000		0.000	

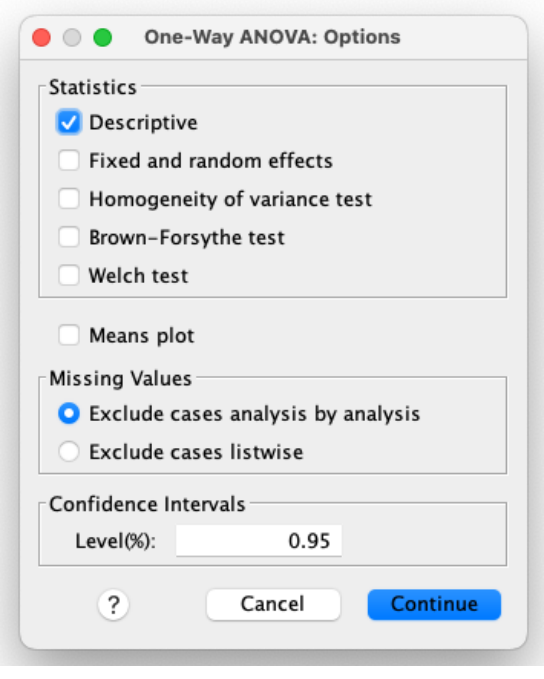
One-way ANOVA: Hypotheses 1 and 2 were tested via one-way ANOVA, using organisational performances (sales growth and employment growth) as dependent variables. The results of the test are shown in Table 5 below.

Consistent results for both indices of organisational performance were obtained, and Hypotheses 1 and 2 are fully supported. It is clearly demonstrated that innovative companies have better performance than non-innovative companies, and that all-round innovators have better performance than adopters or creators.

ANOVA with SPSS

- Analyze – Compare Means – One-way ANOVA





ANOVA with SPSS

From means we see that older people are more willing to repair or reuse items.

Descriptives

GREEN2 I try to repair or reuse items rather than throwing them away.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
18 to 24	9	5.3333	1.32288	.44096	4.3165	6.3502	3.00	7.00
25 to 34	91	5.3407	1.45465	.15249	5.0377	5.6436	1.00	7.00
35 to 44	56	5.6429	1.35417	.18096	5.2802	6.0055	1.00	7.00
45 to 54	29	6.1724	.88918	.16512	5.8342	6.5106	4.00	7.00
55 to 64	10	5.8000	.91894	.29059	5.1426	6.4574	4.00	7.00
65 plus	5	6.4000	.54772	.24495	5.7199	7.0801	6.00	7.00
Total	200	5.5950	1.33788	.09460	5.4084	5.7816	1.00	7.00

➔ **Oneway**

The p-value is significant. Age has a statistically significant impact on the attitude towards repairing or reusing items.

ANOVA

GREEN2 I try to repair or reuse items rather than throwing them away.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.960	5	3.992	2.303	.046
Within Groups	336.235	194	1.733		
Total	356.195	199			

Thank you!