THE UNIVERSITY OF NEWCASTLE AUSTRALIA

How to analyse my data
3- 5 July 2019

Outlines

- **Exploratory data analysis and visualising data**
- **Formulating research questions**
- **Data types and related statistical tests**
- **How to interpret statistical results**

- **Explanation of common statistical tests**
- **Workbook with worked examples then hands on practice**
- **Use statistical software to create output (SPSS)**
- **SPSS software guide provided**
- **Focus on understanding, concepts and interpretation of results**

Instructor
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Statistical Support Service

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Statistical Support Service

Statistics refresher seminar series

What method do I use?

12-June-2019

Presenter: Nic Croce

(Notes thanks to Kim Colyvas)

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Notes for this Seminar can be downloaded from:

http://www.newcastle.edu.au/about-uon/governance-and-leadership/faculties-and-schools/faculty-of-science-and-information-technology/resources/statistical-support-services

***or search the UoN website for StatSS**

What Method do I use?

1. The Research Question
2. The Variable Types – numeric / categorical
3. Commonly used Analysis Methods
   - Chi squared test
   - McNemar Test
   - Paired (dependent) t-test
   - Independent samples t-test
   - ANOVA (repeated measures)
   - Simple/Multiple Linear Regression
   - Factor Analysis

Research questions

- When framing research questions they begin generally.
- The choice of a statistical method however is made easier by refining the question and making it specific.
- Eg Example 3 from later in the notes…

  'We want to explore the idea that in children, exercise and medication can help with their asthma.'

Specific research questions

http://libguides.lmu.edu/content.php?pid=10084&sid=1965230

‘We want to explore the idea that in children, exercise and medication can help with their asthma.’

Specific research questions

http://libguides.lmu.edu/content.php?pid=10084&sid=1965230

'We want to explore the idea that in children, exercise and medication can help with their asthma.'

A <u>general</u> version

Do exercise and/or medication benefit asthmatic children?

Specific research questions

http://libguides.lmu.edu/content.php?pid=10084&sid=1965230

'We want to explore the idea that in children, exercise and medication can help with their asthma.'

A general version

Do exercise and/or medication benefit asthmatic children?

More specific - measurable/countable variables

Does **mean** Forced Expiratory Volume (1 sec) **increase** by **increasing** exercise (...) and **increasing** medication (...) in asthmatic children aged 7-12 yrs?

The Question determines the analysis

Response -Y- (outcome, dependent) variable(s)

- List variable(s) measured on experimental unit.
- What is/are the response variable type(s)?
- If categorical how many levels within the category?
- If multiple response variables are they correlated?

Explanatory -X- (predictor, independent) variable(s)

- List variables.
- What are variable types?
- Number of groups (samples) being studied (2 or multiple).
- Relationship between samples: Independent/Dependent
- Are multiple explanatory variables correlated?

Some goals of analysis

- Are there differences due to a given variable(s)?
- Relationships – describe, predict effect of a variable(s)
- Determine the relative importance of variables.
- Create new variables or groupings

Variable types → ★ key ★

- **Numeric** – measures and counts
  - **Continuous :** temperature, weight, speed, distance (*Similar terms include scale and ratio)*
  - **Discrete :** # of defects, result of die toss, item count
- **Categorical** – values based on categories
  - **Ordinal :** Grades - FF, P, C, D, HD, *Temperature - Low, Medium, High
  - **Nominal :** gender – male/female colour - blue/green/yellow

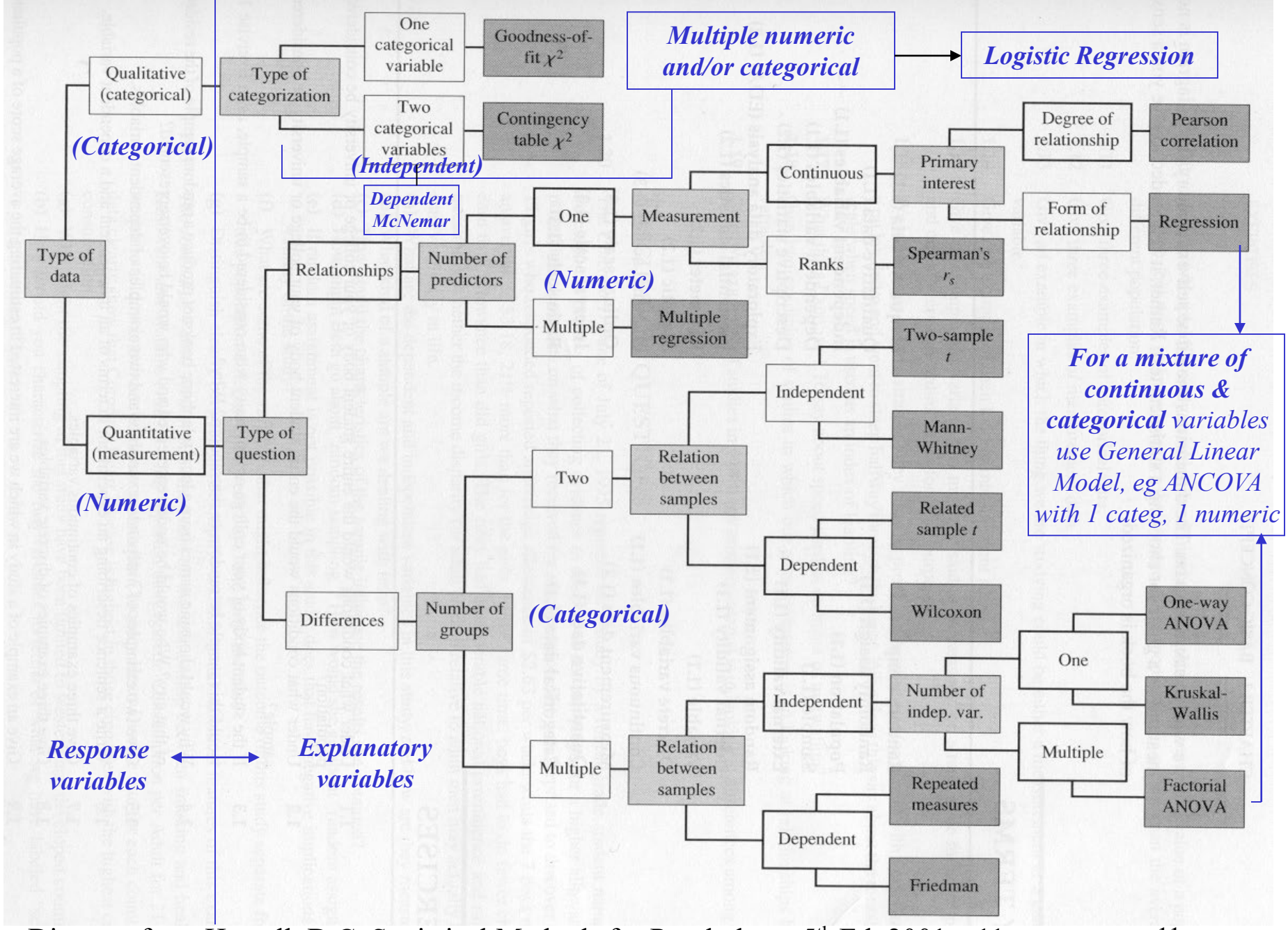

Diagram from Howell, D.C, Statistical Methods for Psychology, 5th Ed, 2001, p11, Duxbury, Thomson Learning with additions *(in blue and italics)* by K. Colyvas (version 5-Jul-05).

Method selection table (a)

Response Y	Explanatory X or A	Specific question(s)	Displays	Statistical method
Singles samples				
Categorical		How is data distributed?	Table Bar chart Pareto	Tables of %'s in categories, n
Numerical		How is data distributed?	Histogram	Tables of summary statistics, eg mean, sd, min, max, quartiles, n.

Method selection table (b)
See next slide

Y Response	X Explanatory	Specific question(s)	Displays	Statistical method
Categorical	Categorical	How do proportions in response depend on **the levels of the explanatory variable?**	Tables	Chi-squared statistic
Categorical	Numerical	How does the proportion in response depend on the **values of the explanatory variable**?	Tables (X groups)	*Logistic regression* *Correlation (for a binary response only)*
Numerical	Categorical	How does mean level in response change with **the levels of the explanatory variable? If so how does it vary?**	Box plots Mean plots CI plots	t test (2 indep groups) ANOVA (3 or more groups)
Numerical	Numerical	How does mean level of response change with **values of the explanatory variable**.	Scatter plots	Correlation Regression
Dependent (or paired) samples				
Categorical	Categorical	Is there agreement between the matched levels? Is lack of agreement biased? Is there a difference in proportions?	Tables	Kappa (2x2 Agreement) McNemar's test (2x2 - bias in agreement or difference in proportions
Numerical	Categorical	How does mean level in response change with the levels of the explanatory variable WITHIN e.g. subject	Box plots Mean plots Within CI plots	Paired t test Repeated measures ANOVA

Multiple response variables (Multivariate)	Specific question(s)	Statistical Method
	How do I reduce the number of variables?	Principal component analysis & Factor analysis.
	Can the variables be categorised into cluster groups?	Cluster analysis.

NB No explanatory variables – only outcomes

How to determine the analysis method
Put the info on the 'desk' – DSQ
Data - Samples - Question

- **D:** variable types matter. Is the data counted or measured ➡ numerical or in categories?
- **S:** how many samples, groups or categories? Are they independent or dependent?
- **Q:** is question about independence, association or relationships? Or are you being asked to compare something or find a difference?

Example 1

Is there a difference between topical treatments used on superficial sites in clearing MRSA (methicillin-resistant Staphylococcus aureus) infections within 14 days for hospitalised patients?

Response Clear of MRSA in 14 days - Yes/No

Type ?

Explanatory Standard treatment, Tea tree oil

Type?

Imagine research objective with a table or graph

	Free of MRSA infection after 14 days			
Treatment	**No**	**Yes**	**Total**	**% Clear**
Standard	30	14	44	32%
Tea tree oil	26	32	58	55%
Total	56	46	102	45%

Method?

Adapted from M.S. Dryden, S. Dailly, M. Crouch, A randomized, controlled trial of tea tree topical preparations versus a standard topical regimen for the clearance of MRSA colonization, Journal of Hospital Infection (2004) 56, 283–286.

Example 1 test

Is there a difference between topical treatments used on superficial sites in clearing MRSA (methicillin-resistant Staphylococcus aureus) infections within 14 days for hospitalised patients?

Response variables

Type(s) Clear of MRSA in 14 days - Yes/No- **Categorical**

Explanatory variables

Type(s) Topical Treatment – standard /tea tree oil - **Categorical**

Dependent? **Independent**

Imagine the result with a table or graph

	Free of MRSA infection after 14 days			
Treatment	**No**	**Yes**	**Total**	**% Clear**
Standard	30	14	44	32%
Tea tree oil	26	32	58	55%
Total	56	46	102	45%

Method - Chi-squared statistic

Dependent (paired/matched) samples

- When repeated observations are made on
  - the same person, eg two different drugs to reduce blood pressure,
  - process or object, eg two different manufacturing lines, or two measuring devices on a sample of stream water, blood etc,
  - includes measurements closely spaced in time - ie longitudinal studies with short rather than long intervals in seeing patients **or** spatially – eg sun skin sun damage will be similar on different sites on a forearm, but very different to underarm areas
- Measurements on matched pairs, e.g. in a case/control study people matched on age and gender, or identical twins (genetic matching).

* Two measurements made on the same person/object/closely spaced in time or spatially are *likely to be closely related*.
The response is likely to be similarly affected so we should NOT treat the measurements as independent.

Example 2

A poll of a random sample of 1600 British voters was taken and 944 indicated approval. Six months later they SAME 1600 people were asked again and 880 indicated approval.

Response & Type

Explanatory & Type

Dependent?
(If so on what?)

First Survey	Second Survey: Approve	Second Survey: Disapprove	Total
Approve	794	150	944
Disapprove	86	570	656
total	880	720	1600

Imagine research objective with a table or graph

Method

	First survey	Second survey
% Approve	59% (944/1600)	55% (880/1600)

Cited in Agresti, A., Categorical Data Analysis, Wiley, 2nd Ed 2000. TABLE 10.1 Rating performance of Prime Minister

Example 2 test

A poll of a random sample of 1600 British voters was taken and 944 indicated approval. Six months later the SAME 1600 people were asked again and 880 indicated approval.

Response & Type - vote (A or D) categorical

Explanatory & Type - vote (A or D) categorical

Dependent

(If so on what?)

Same people

Imagine research objective with a table or graph

First Survey	Second Survey: Approve	Second Survey: Disapprove	Total
Approve	794	150	944
Disapprove	86	570	656
total	880	720	1600

Method

McNemar

	First survey	Second survey
% Approve	59% (944/1600)	55% (880/1600)

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Exercise 3: Paired or unpaired samples?

a) A manufacturer has several hundred employees manufacturing ergonomic desks. Two new designs are being evaluated with respect to manufacturing time as all other the costs of production are similar. A random sample of 20 workers are drawn with the first 10 requested to manufacture desk type A and the second 10 workers to manufacture desk type B.

What is the response?_____

What is the factor? _____

Are the two samples dependent or independent? _____

b)Consider the situation above but now have all 20 people manufacturing desk type A and then the same 20 people manufacturing desk type B.

Are the two samples dependent or independent? _____

Exercise 3: Paired or unpaired samples?

a) A manufacturer has several hundred employees manufacturing ergonomic desks. Two new designs are being evaluated with respect to manufacturing time as all other the costs of production are similar. A random sample of 20 workers are drawn with the first 10 requested to manufacture desk type A and the second 10 workers to manufacture desk type B.

What is the response? Time

What is the factor? Type

Are the two samples dependent or independent? Independent

b)Consider the situation above but now have all 20 people manufacturing desk type A and then the same 20 people manufacturing desk type B.

Are the two samples dependent or independent? Dependent

Imagine the results – 3b. dependent study

Assume mean time for A = 60 mins, typical variability **between** workers is ± 10 mins. Average improvement of B relative to A is 2

	Desk Type		
Worker	**A**	**B**	**A-B**
1			
2			
3			
4			
⋮			
20			
Mean			
Sd			

Paired or unpaired

a. **2 sample t-test**

Calculates the differences between the 2 sample means

b. **Paired t-test**

Calculates the mean of the differences between pairs

* Removal of the effect of variability between people allows the focus to be on the difference between the manufacture of the desk types. This gives more power.

Example 3 – method comparisons

Using the two study designs from the paired/unpaired exercise

Imagine research objective with a table or graph

Methods

	Desk Type		
Worker	**A**	**B**	**A-B**
1	56.5	55.2	1.3
2	54.7	50.6	4.1
3	71.4	68.9	2.5
4	52.9	50.4	2.5
20	57.6	53.6	4.0

			Mean diff
Mean	59.7	57.4	2.27
sd	6.3	6.3	1.00
diff of means	**2.26**		
t	1.14		10.2
df	38		19
p	0.263		0.000

Independent ⟺ Dependent

Obvious!

Easy to see that the paired t-test is better so why then do we see the 2 sample t-test being used???

Study design!

=> Time and money – not always possible to set up the optimal study. Difficult to gain

- repeated observations on people/objects
- or closely spaced time/spatially
- or matched pairs / case - control

Example 4

A physiotherapist treated 17 patients with dizziness (diagnosed as cervical in origin) using sustained natural apophyseal glide (SNAG). A placebo group (n=17) was used for comparison. A Dizziness Handicap Inventory (DHI - larger is worse) was measured on both groups at baseline, post treatment and 6 wks and 12 wks post treatment.

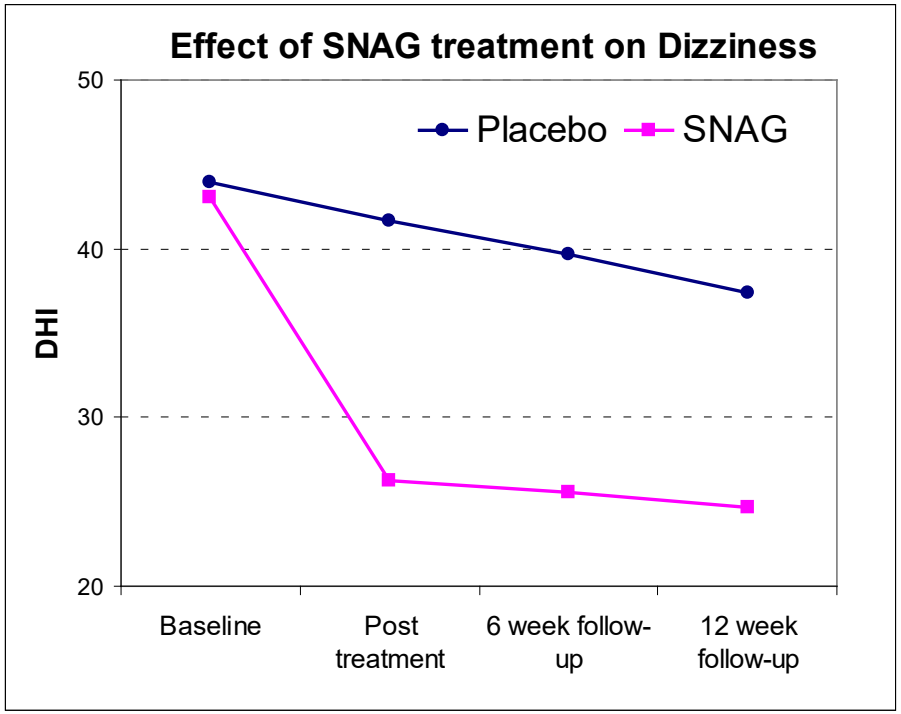
Response & Type

Explanatory & Type

Dependent? (On what?)

Imagine research Objective

Method



Sue Reid, Research masters project, 2005
University of Newcastle

Example 4 test

A physiotherapist treated 17 patients with dizziness (diagnosed as cervical in origin) using sustained natural apophyseal glide (SNAG). A placebo group (n=17) was used for comparison. A Dizziness Handicap Inventory (DHI - larger is worse) was measured on both groups at baseline, post treatment and 6 wks and 12 wks post treatment.

Response & Type – DHI continuous/numerical

Explanatory & Type – treatment (2) + time (4) categorical

Dependent (On what?)

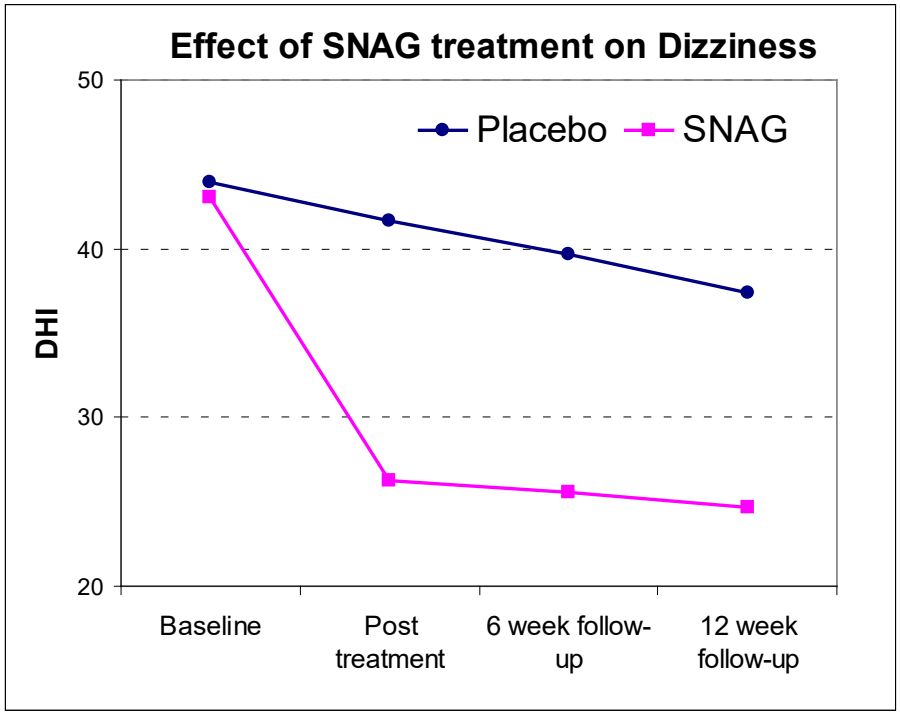
time – dependent on person

Imagine research

Objective

Method

Repeated measures ANOVA



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Example 5

A large chain of motor inns that focuses on the business customer is looking for a better way to choose new locations for establishing a new motel. Data from 100 randomly chosen locations has been collected. The objective is to predict which sites are most profitable (Operating margin) using the variables total number motel + hotel rooms within 3 miles, number of miles to nearest competition, median household income, office space in surrounding community, distance to CBD.

Response

Explanatory

Dependent?

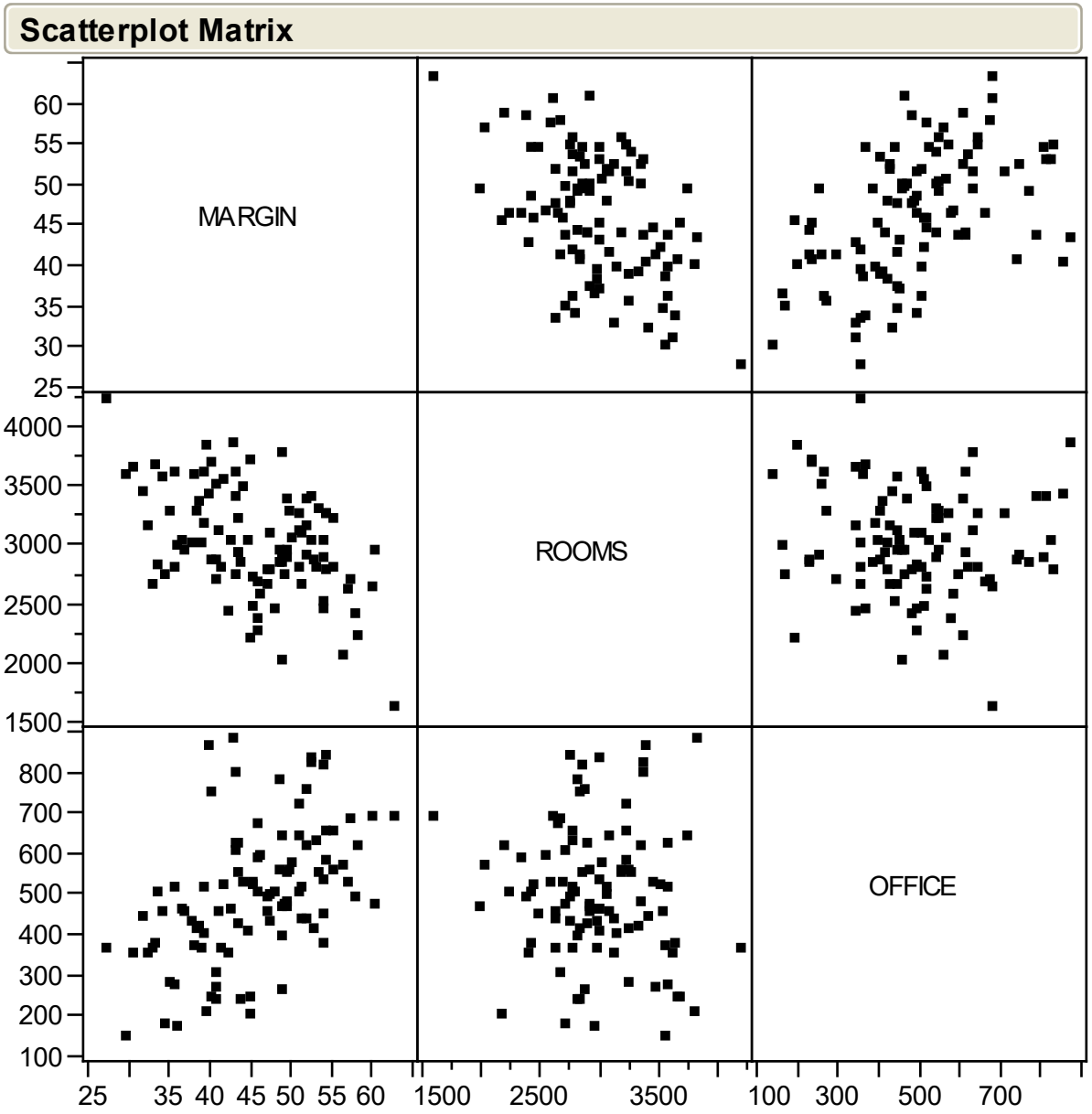
Imagine graph and/or table

Method

Correlation matrix

	MARGIN	ROOMS	OFFICE
MARGIN	1.00	-0.47	0.50
ROOMS	-0.47	1.00	-0.09
OFFICE	0.50	-0.09	1.00

Eg 5 scatterplot - correlation



Example 5 test

relationship

A large chain of motor inns that focuses on the business customer is looking for a better way to choose new locations for establishing a new motel. Data from 100 randomly chosen locations has been collected. The objective is to predict which sites are most profitable (Operating margin) using the variables total number motel + hotel rooms within 3 miles, number of miles to nearest competition, median household income, office space in surrounding community, distance to CBD.

Response - operating margin - numerical

Explanatory - motels, rooms, miles, income, office, CBD -numerical

Dependent? Indep - OM measured once

Imagine graph and/or table

Method - Regression

Correlation matrix

	MARGIN	ROOMS	OFFICE
MARGIN	1.00	-0.47	0.50
ROOMS	-0.47	1.00	-0.09
OFFICE	0.50	-0.09	1.00

My project - Description, hypothesis, aim etc

Response variables
Type(s)
Explanatory variables
Type(s)
Dependent? (On what)?

Imagine the result with a table or graph

Method

Break in lecture
for 5-10 mins
for class exercise

Example 6

People with back/neck pain were treated either with fake needles, control group (n=27), or real needles (n=25) to assess the effect of acupuncture on back/neck pain. Pain scores (questionnaire: 0=bad, 100=good) were recorded on each patient before and after treatment.

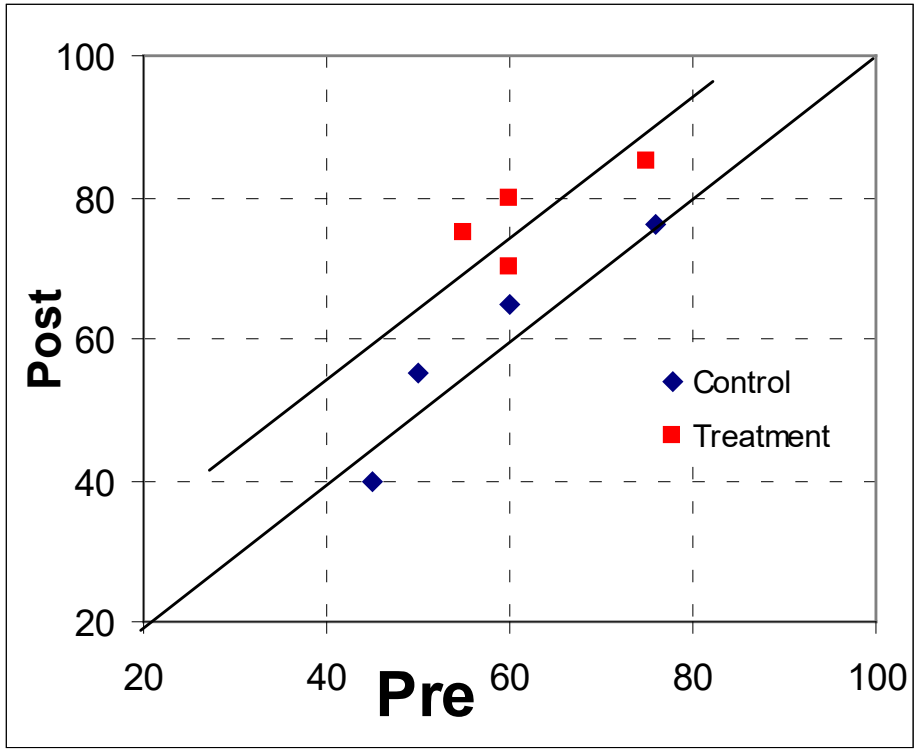
Response

Explanatory

Dependent? (On what?)

Imagine research objective

Method



Described in Vickers, A.J. and Altman, D.G., Analysing Controlled Trials with baseline and follow-up measurements, British Medical Journal, 2001, 323, 1123-4.

Example 6 test

relationship

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Response **pain scores**

numerical

Explanatory

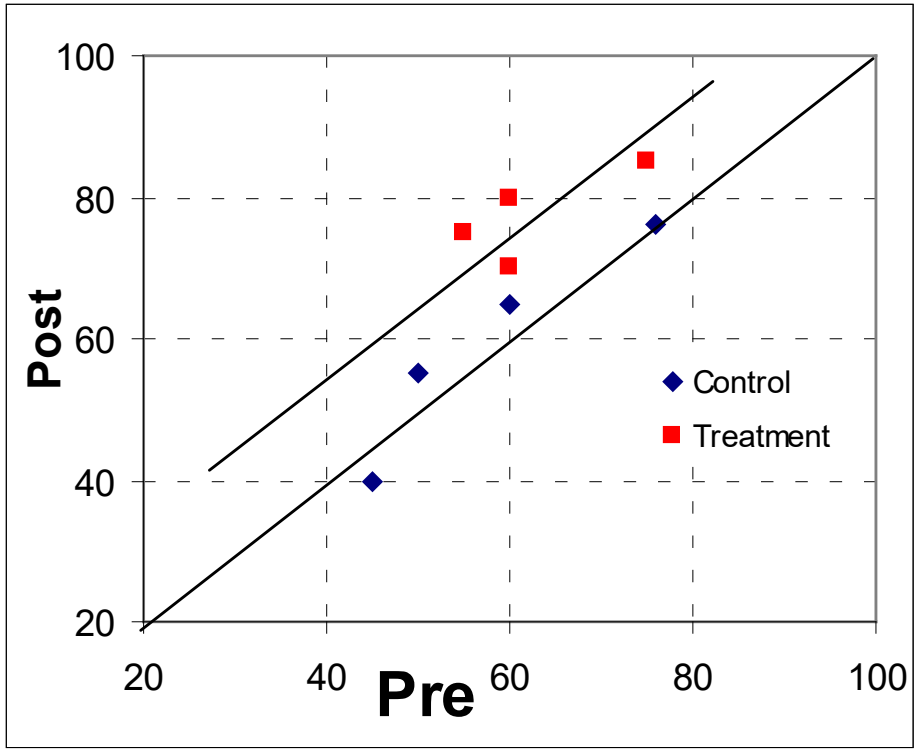
Dependent on individuals

measured 2x (pre/post)

Imagine research objective

Method

Repeated measures regression



Described in Vickers, A.J. and Altman, D.G., Analysing Controlled Trials with baseline and follow-up measurements, British Medical Journal, 2001, 323, 1123-4.

Example 7

The relative importance of genetic and environmental factors impacting the incidence of melanoma were examined. Families with high incidence of melanoma (3 or more members with melanoma) were studied by collecting information for each person in the extended family. The status of two suspect genetic mutations (mutation/no mutation) as well as skin colour, extent of sun skin damage, number of moles, number of freckles as other factors were measured.

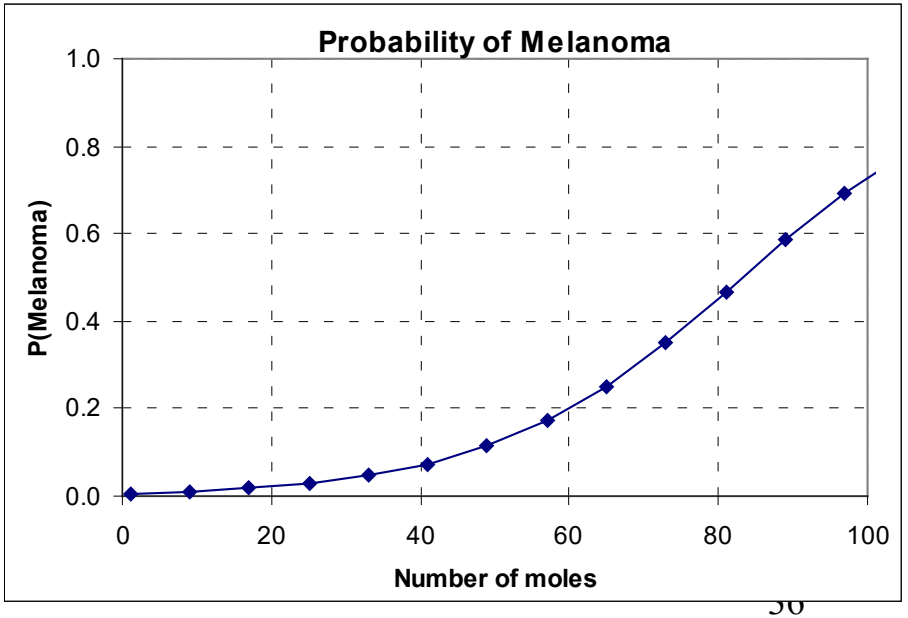
Response

Explanatory

Dependent? (on what?)

Imagine graph

Method



Example 7 test

relationship

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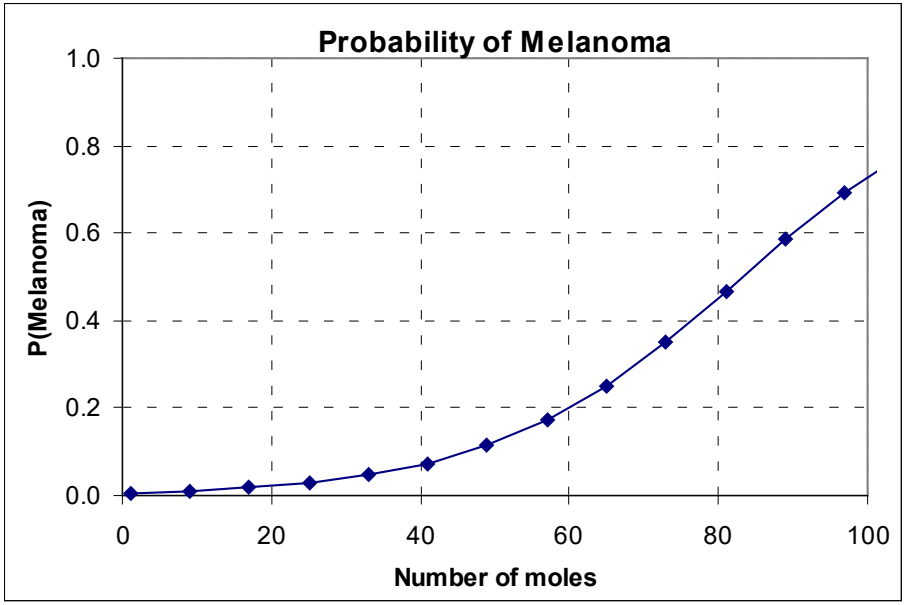
Response melanoma Y/N categorical

Explanatory no. of moles numerical

Dependent? (on what?) indep

Imagine graph

Method logistic regression



Multivariate methods

- **Creating new variables** (latent variables)
  - have more desirable properties than an individual variable, eg psychological scales for depression, anxiety and stress,
  - Simplification – fewer variables summarise many
- **Classification (clusters)**
- **Relationships among/between variables**
  - unusual features in data, including outliers,
  - multivariate normality,
  - modelling relationships (SEM)
  - prediction of one group of variables by another group regression of Xs on Ys (PCR, PLS)

TABLE 1.1

Cross-listing of multivariate methods and problem types

	Multivariate technique								
Problem type	PCA	FA	DA	CDA	CA	MANOVA	CVA	CCA	**PCR, PLS**
Exploring relationships among variables	Sometimes	Definitely	Never	Never	Never	Never	Rarely	Sometimes	Sometimes & between variables
Screening data	Definitely	Sometimes	Never	Never	Sometimes	Never	Never	Never	Definitely
Creating new variables	Does	Does	Does not	Does	Does not	Does not	Does	Does	Does
Predicting group membership	Does not	Does not	Does	Does	Does	Does not	Does not	Does not	Does
Comparing group means	Possibly	Possibly	Rarely	Rarely	Does not	Does	Does	Does not	Does
Comparing groups of variables	Possibly	Possibly	Never	Never	Never	Never	Never	Definitely	Definitely
Verifying clusters	Definitely	Possibly	Never	Never	Definitely	Never	Never	Never	Definitely
Reducing dimensionality	Definitely	Definitely	Never	Definitely	Never	Never	Definitely	Definitely	Definitely
Creating meaningful variables	Unlikely	Usually	Never	Possibly	Never	Never	Possibly	Unlikely	Unlikely

from Johnson, D.E, Applied Multivariate Methods for Data Analysis, 1998, Duxbury

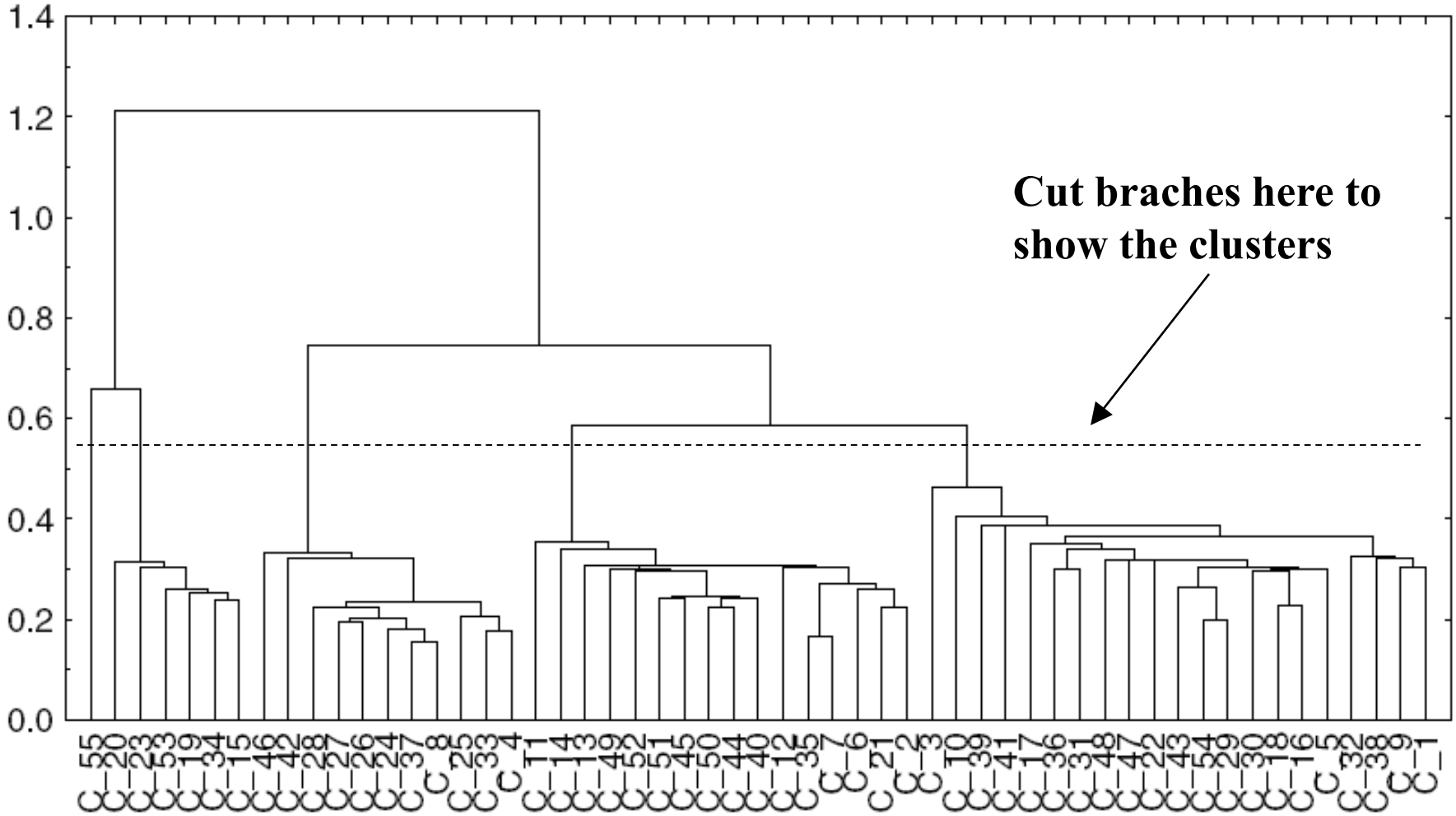
PCA – Principal Components Analysis, FA – Factor Analysis, DA – Discriminant Analysis, CDA – Canonical Discriminant Analysis, CA – Cluster Analysis, MANOVA – Multivariate ANOVA, CVA – Canonical Variates Analysis, CCA – Canonical Correlation Analysis, PLS – Partial Least Squares

Example 8 – Cluster and FA

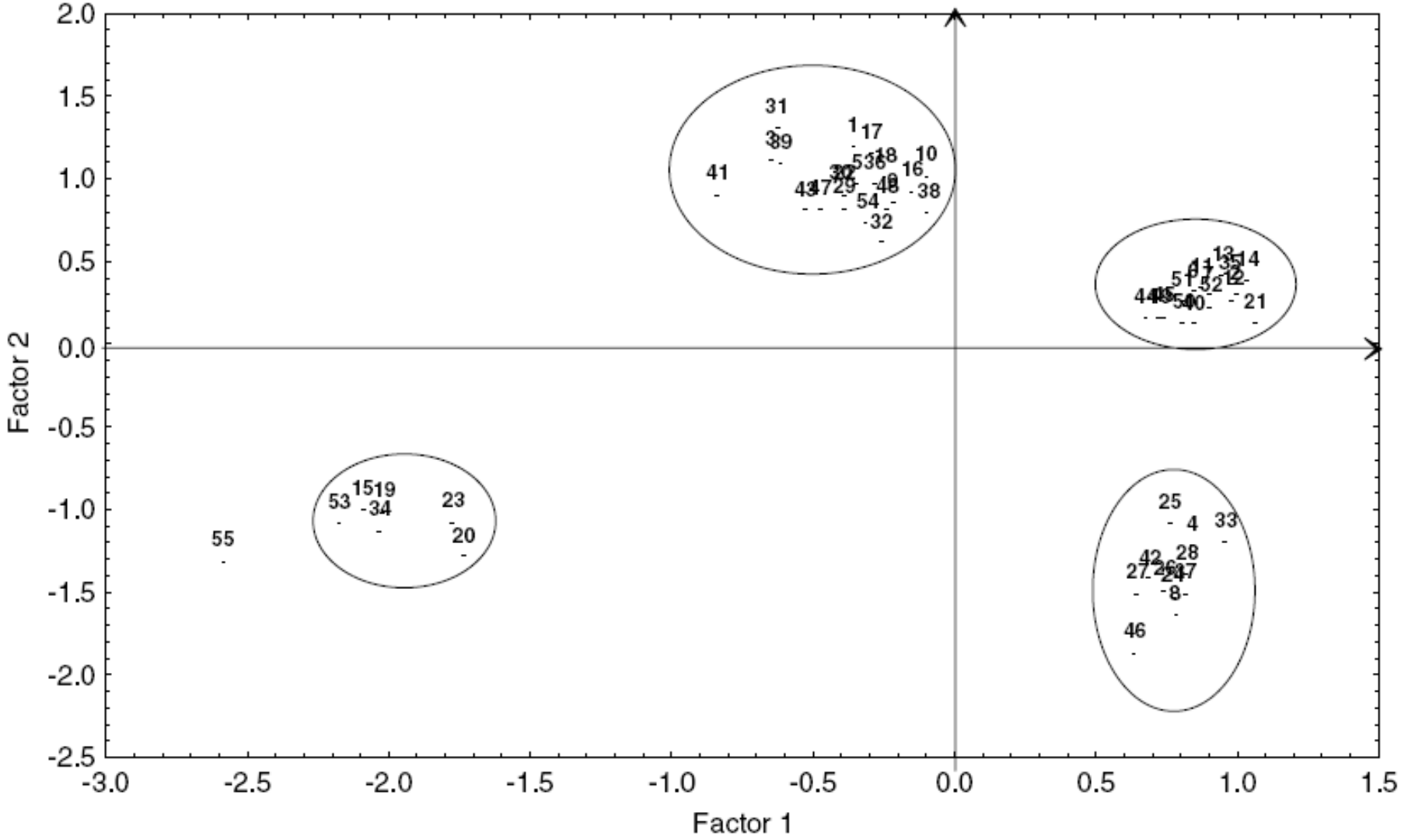
Abstract Radioisotope x-ray fluorescence (XRF) analysis has been utilized to determine the elemental composition of 55 archaeological pottery samples by the determination of 15 chemical elements. Fifty-four of them came from the Tel-Alramad site in Katana town, near Damascus city, Syria, and one sample came from Brazil. The XRF results have been processed using two multivariate statistical methods, **cluster and factor analysis**, in order to determine similarities and correlation between the selected samples based on their elemental composition. The methodology successfully separates the samples where four distinct chemical groups were identified.

E. H. Bakraji, Application of multivariate statistical methods to classify archaeological pottery from Tel-Alramad site, Syria, based on x-ray fluorescence analysis, *X-Ray Spectrom.* 2006; **35**: 190–194

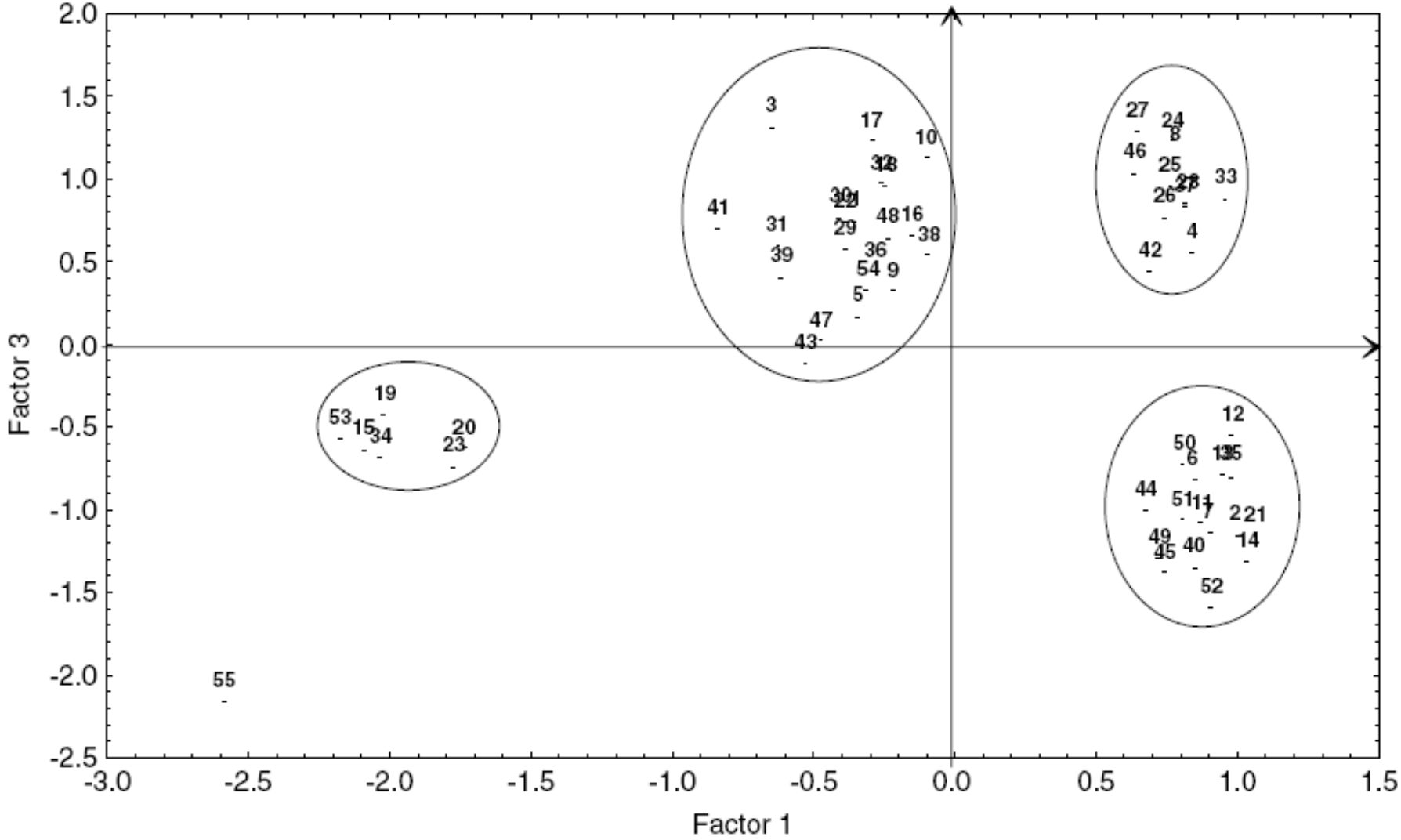
Clustering – tree diagram – based on distance apart



Clusters based on factor analysis plot of factor scores
FA1 vs FA 2



Clusters based on factor analysis plot of factor scores FA1 vs FA 3



Factor loadings (correlations)

Table 2. Factor loading for the samples data set. Fifteen elements, maximum likelihood factor analysis, varimax rotation

Elements	Factor 1	Factor 2	Factor 3	Communality
Br	−0.21	0.15	0.47	0.29
Ca	0.31	0.92	0.07	0.94
Cu	−0.70	−0.68	0.08	0.95
Fe	0.25	0.30	0.81	0.81
Ga	−0.73	−0.60	−0.20	0.93
K	0.13	−0.03	0.57	0.34
Mn	−0.30	0.28	0.38	0.31
Ni	−0.14	−0.80	−0.39	0.81
Pb	0.08	−0.87	−0.08	0.77
Rb	0.97	0.03	0.17	0.98
Sr	−0.34	0.80	0.30	0.85
Ti	0.02	0.81	0.02	0.65
Y	0.88	−0.14	0.17	0.83
Zn	−0.34	−0.53	−0.50	0.65
Zr	0.93	0.08	−0.11	0.89
Variance explained by factors (%)	36.4	26.3	10.6	73.3

Three factors explain most of the variation (73.3%), i.e. 15 variables simplified to 3.

Loadings identify the most important variables in each factor – the larger the absolute value of the loading the more important the variable.
eg Ga, Cu, Rb, Y and Zr in Factor 1

Example 9

A Pizza firm carried out a 15 question employee attitude survey with male and female kitchen staff, delivery drivers, shift supervisors and assistant managers participating.

(Next Slide for questions)

Response

Explanatory

Imagine the result with a table or graph

Method

Table 1.5 Final interpretation of factors for non-supervisory staff

Create 4 new variables from 15 - Factor Analysis

1 Company Pride	2 Lack of commitment	3 Willingness to work hard	4 Attitude to employees	Short version of question	Full text of question
1				2 Great Company	2. I TALK UP PIZZAZZ TO FRIENDS AS A GREAT COMPANY TO WORK FOR.
1				4 Any job to stay	4. I WOULD ACCEPT ALMOST ANY TYPE OF JOB IN ORDER TO STAY WITH PIZZAZZ.
1				5 Values similar	5. MY VALUES AND PIZZAZZ'S VALUES ARE SIMILAR.
1				6 Proud tell others	6. I AM PROUD TO TELL OTHERS THAT I WORK FOR PIZZAZZ.
1				8 Inspires best	8. PIZZAZZ REALLY INSPIRES ME TO DO MY BEST.
1				10 Glad chose Pizzazz	10. I AM GLAD THAT I CHOSE PIZZAZZ TO WORK FOR.
1				13 Care about what happens	13. I REALLY CARE ABOUT WHAT HAPPENS TO PIZZAZZ.
1				14 Best company work for	14. FOR ME THIS IS THE BEST COMPANY TO WORK FOR.
	2			3 Little Loyalty	3. I FEEL VERY LITTLE LOYALTY TO PIZZAZZ.
	2			7 Other Co. work similar	7. I COULD JUST AS WELL BE WORKING FOR ANOTHER COMPANY AS LONG AS THE WORK WAS SIMILAR.
	2			9 Little change to leave	9. IT WOULD TAKE VERY LITTLE CHANGE IN MY WORK TO CAUSE ME TO LEAVE PIZZAZZ.
	2			11Not much gained long time	11. THERE'S NOT MUCH TO BE GAINED BY STAYING AT PIZZAZZ A LONG TIME.
	2			15 Work Pizzazz a mistake	15. DECIDING TO WORK FOR PIZZAZZ WAS A MISTAKE.
		3		1 Work Harder	1. I AM WILLING TO WORK HARDER THAN MOST PEOPLE AT PIZZAZZ.
			4	12 Difficult agree attitudes	12. I OFTEN FIND IT DIFFICULT TO AGREE WITH PIZZAZZ'S ATTITUDES TO ITS EMPLOYEES.

Example 9 test

A Pizza firm carried out a 15 question employee attitude survey with male and female kitchen staff, delivery drivers, shift supervisors and assistant managers participating.

Response questions **categorical** **response to survey**

Explanatory **none**

Imagine the result with a table or graph

Method **Factor Analysis**

Review & considerations – DSQ
Data - Samples - Question

- Variable types matter – numerical or categorical :**Data**
- Variable types determine the method of analysis where there is a causal relationship
- Independent or dependent samples :**Samples**
- Multiple response variables – relationships among the repeated measures. May lead to variable reduction by grouping together variables by some common factor :**Question**

Additional resources

- Forming a research question

http://libguides.lmu.edu/c.php?g=323167&p=2173967

- Statistics Learning Centre Videos and Resources on youtube

http://www.youtube.com/watch?v=0r2o2Okpt3A

Thank you

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How to analyse my data
3- 5 July 2019

Outlines

- **Exploratory data analysis and visualising data**
- **Formulating research questions**
- **Data types and related statistical tests**
- **How to interpret statistical results**

- **Explanation of common statistical tests**
- **Workbook with worked examples then hands on practice**
- **Use statistical software to create output (SPSS)**
- **SPSS software guide provided**
- **Focus on understanding, concepts and interpretation of results**

Instructors
Nic Croce

Statistical Support Service

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Statistical Support Service

Statistical advice, mentoring or analysis

- Free consultation is available for FSCI staff and PhD students
- Approval must be obtained from your HOS
- Supervisors attend with their PhD students
- $125 per hour for non-FSCI
- Paying? It may sound like a lot but early advice on your research can make it more efficient and effective saving you money, time, effort, frustration, anxiety ... !
- You can also learn how to do the analysis yourself. We can teach or guide you how to use statistical software.

Slide 3 has the StatSS link to the appointment form