

Multiple Linear Regression II



Lecture 8

Survey Research & Design in Psychology
James Neill, 2012

Overview



1. Summary of MLR I
2. Partial correlations
3. Residual analysis
4. Interactions
5. Analysis of change
6. Summary of MLR II
7. MLR II quiz – practice questions

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Readings - MLR

As per
previous
lecture

1. Howell (2009).
Correlation & regression
[Ch 9]
2. Howell (2009).
Multiple regression
[Ch 15; not 15.14 Logistic Regression]
3. Tabachnick & Fidell (2001).
Standard & hierarchical regression in
SPSS (includes example write-ups)
[Alternative chapter from eReserve]

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Summary of MLR I

- Check assumptions
 - LOM
 - N
 - Normality
 - Linearity
 - Homoscedasticity
 - Collinearity
 - MVOs
 - Residuals

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Summary of MLR I

- Choose type
 - Standard
 - Hierarchical
 - Stepwise
 - Forward
 - Backward

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Summary of MLR I

- Interpret
 - Overall
 - R^2
 - Changes in R^2 (if hierarchical)
 - For each IV:
 - Coefficients
 - Standardised
 - Unstandardised
 - Partial correlations

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Summary of MLR I

- Equation

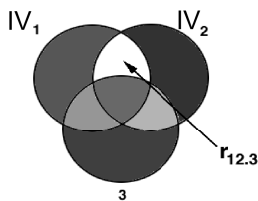
- Report if useful (e.g., is the study predictive?)

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Partial correlations (r_p)



r_p between X and Y after controlling for (partially out) the influence of a 3rd variable from both X and Y.



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Partial correlations (r_p): Examples

- Does years of marriage (IV_1) predict marital satisfaction (DV) after number of children (IV_2) is controlled for?
- Does time management (IV_1) predict university student satisfaction (DV) after general life satisfaction (IV_2) is controlled for?

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Partial correlations (r_p) in MLR

- When interpreting MLR coefficients, compare the 0-order and partial correlations for each IV → draw a Venn diagram
 - Partial correlations will be equal to or smaller in magnitude than the 0-order correlations
 - If a partial correlation is the same as the 0-order correlation, then the IV operates independently on the DV.

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Partial correlations (r_p) in MLR

- To the extent that a partial correlation is smaller than the 0-order correlation, then the IV's explanation of the DV is shared with other IVs.
- An IV may have a sig. 0-order correlation with the DV, but a non-sig. partial correlation. This would indicate that there is non-sig. unique variance explained by the IV.

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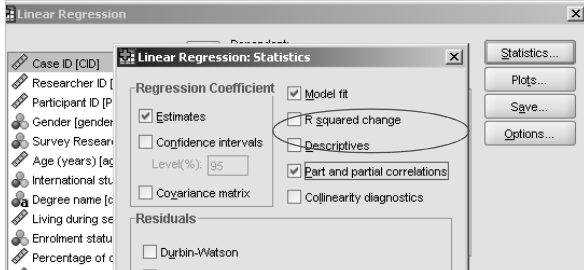
Semi-partial correlations (sr^2) in MLR

- The sr^2 indicate the %s of variance in the DV which are uniquely explained by each IV.
- In SPSS, the srs are labelled “part”. Square these to get sr^2 .
- For more info, see Allen and Bennett (2008, p. 182)

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How to obtain part & partial correlations in SPSS

In Linear Regression - Statistics dialog box, check "Part and partial correlations"

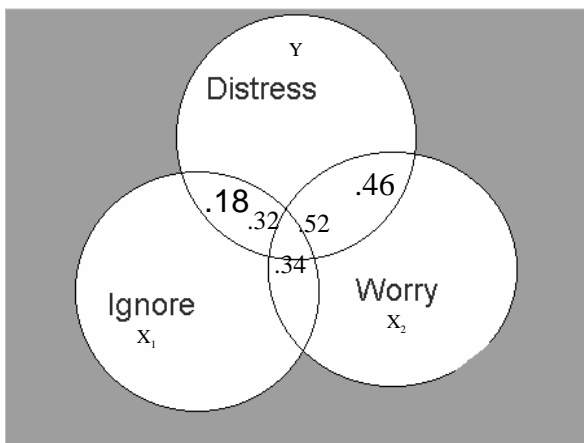


Multiple linear regression - Example

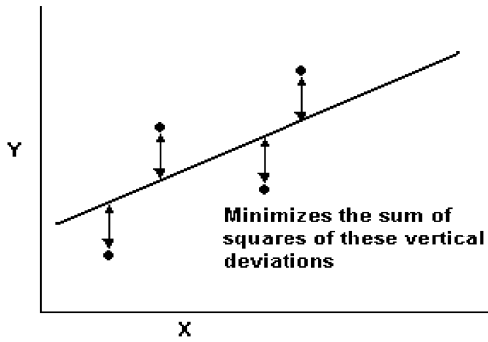
Coefficients^a

Model		Correlations	
		Zero-order	Partial
1	Worry	-.521	-.460
	Ignore the Problem	-.325	-.178

a. Dependent Variable: Psychological Distress



Residual analysis



Residual analysis

Three key assumptions can be tested using plots of residuals:

1. **Linearity:** IVs are linearly related to DV
2. **Normality of residuals**
3. **Equal variances** (Homoscedasticity)

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Residual analysis

Assumptions about residuals:

- Random noise
- Sometimes positive, sometimes negative but, on average, 0
- Normally distributed about 0

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Residual analysis

Linear Regression: Plots [X]

Scatter 1 of 1

DEPENDENT: *ZPRED, *ZRESID, *DRESID, *ADJPRED, *SRESID, *SDRESID

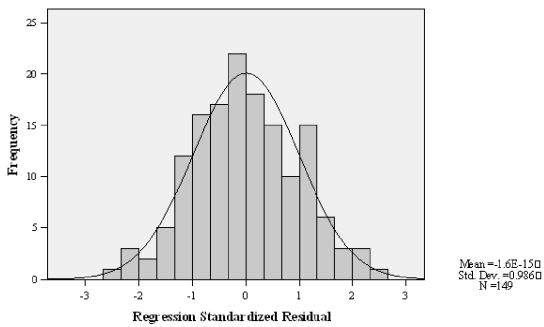
Y: *ZRESID, X: *ZPRED

Standardized Residual Plots: Histogram, Normal probability plot, Produce all partial plots

Buttons: Previous, Next, Continue, Cancel, Help

Residual analysis

Dependent Variable: English Achievement



Residual analysis

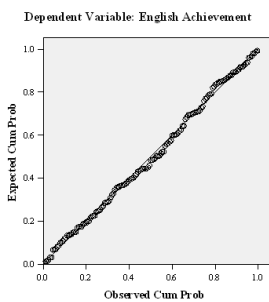
“The **Normal P-P** (Probability) **Plot of Regression Standardized Residuals** can be used to assess the assumption of normally distributed residuals.

If the points cluster reasonably tightly along the diagonal line (as they do here), the residuals are normally distributed.

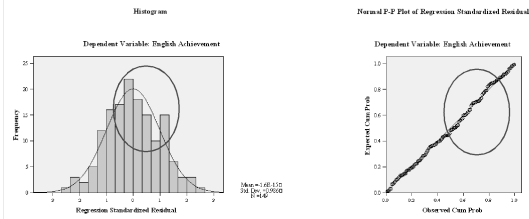
Substantial deviations from the diagonal may be cause for concern.”

Allen & Bennett, 2008, p. 183

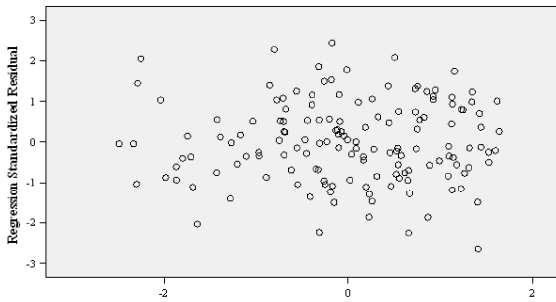
Normal P-P Plot of Regression Standardized Residual



Residual analysis



“The Scatterplot of standardised residuals against standardised predicted values can be used to assess the assumptions of normality, linearity and homoscedasticity of residuals. The absence of any clear patterns in the spread of points indicates that these assumptions are met.”
Allen & Bennett, 2008, p. 183



Why the big fuss about residuals?

↑ assumption violation

→

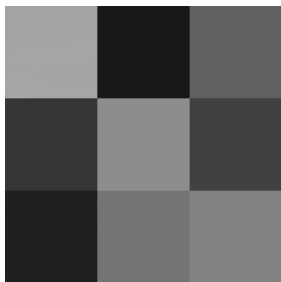
↑ Type I error rate
(i.e., more false positives)

Why the big fuss about residuals?

- Standard error formulae (which are used for confidence intervals and sig. tests) work when residuals are well-behaved.
- If the residuals don't meet assumptions these formulae tend to underestimate coefficient standard errors giving overly optimistic p -values and too narrow CIs.

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Interactions



Interactions

- Additivity refers to the assumption that the IVs act independently, i.e., they do not interact.
- However, there may also be interaction effects - when the magnitude of the effect of one IV on a DV varies as a function of a second IV.
- Also known as a moderation effect.

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Interactions

Some drugs interact with each other to reduce or enhance other's effects e.g.,

Pseudoephedrine → ↑ Arousal

Caffeine → ↑ Arousal

Pseudoeph. X Caffeine → ↑↑↑ Arousal



X



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Interactions

Physical exercise in natural environments may provide multiplicative benefits in reducing stress e.g.,

Natural environment → ↓ Stress

Physical exercise → ↓ Stress

Natural env. X Phys. ex. → ↓↓↓ Stress



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Interactions

- Model interactions by creating cross-product term IVs, e.g.,:
 - Pseudoephedrine
 - Caffeine
 - Pseudoephedrine x Caffeine (cross-product)
- Compute a cross-product term, e.g.,:
 - Compute PseudoCaffeine = Pseudo*Caffeine.

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Interactions

$$Y = b_1x_1 + b_2x_2 + b_{12}x_{12} + a + e$$

- b_{12} is the product of the first two slopes ($b_1 \times b_2$)
- b_{12} can be interpreted as the amount of change in the slope of the regression of Y on b_1 when b_2 changes by one unit.

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Interactions

- Conduct Hierarchical MLR
- Step 1:
 - Pseudoephedrine
 - Caffeine
- Step 2:
 - Pseudo x Caffeine (cross-product)
- Examine ΔR^2 , to see whether the interaction term explains additional variance above and beyond the direct effects of Pseudo and Caffeine.

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Interactions

Possible effects of Pseudo and Caffeine on Arousal:

- None
- Pseudo only (incr./decr.)
- Caffeine only (incr./decr.)
- Pseudo + Caffeine (additive inc./dec.)
- Pseudo x Caffeine (synergistic inc./dec.)
- Pseudo x Caffeine (antagonistic inc./dec.)

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Interactions

- Cross-product interaction terms may be highly correlated (multicollinear) with the corresponding simple IVs, creating problems with assessing the relative importance of main effects and interaction effects.
- An alternative approach is to run separate regressions for each level of the interacting variable.

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Interactions – SPSS example

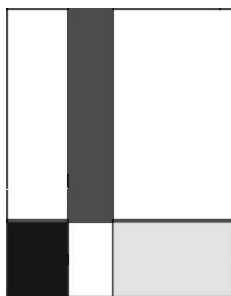
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change
1	.543 ^a	.295	.288	17.34399	.295
2	.547 ^b	.299	.289	17.33241	.004

a. Predictors: (Constant), Caffeine, Pseudoephedrine

b. Predictors: (Constant), Caffeine, Pseudoephedrine, PseudoCaffeine interaction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	57.705	5.109		11.296	.000
	Pseudoephedrine	11.511	1.510	.464	7.625	.000
	Caffeine	4.735	1.780	.162	2.660	.008
2	(Constant)	42.730	14.137		3.023	.003
	Pseudoephedrine	18.137	6.025	.732	3.010	.003
	Caffeine	10.126	5.069	.346	1.998	.047
	PseudoCaffeine interaction	-2.313	2.036	-.380	-1.136	.257

Analysis of Change



Analysis of change

There are two ways MLR can be used to analyse the variance of changes over time:

1. Create difference scores (Time 2 – Time 1) and use these as DVs in a standard MLR
2. Use hierarchical MLR to “partial out” pre-intervention individual differences from the DV (by using the Time 2 score as the DV and the Time 1 score as the Step 1 IV), leaving only the variances of the changes in the DV b/w pre- and post-intervention for analysis in Step 2.

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Analysis of change

Example research question:

In group-based mental health interventions, does the quality of social support from group members (IV2) explain changes in participants' mental health between the beginning (IV1) and end of the intervention (DV)?

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Analysis of change

Hierarchical MLR

- DV = Mental health after the intervention
- Step 1
 - IV1 = Mental health before the intervention
- Step 2
 - IV2 = Support from group members

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Analysis of change

Results of interest

- Change in R^2 – how much variance in change scores is explained by the predictors
- Regression coefficients for predictors in step 2

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Summary (MLR II)

• Partial correlation

- Unique variance explained by each of the Ivs
- Calculate and report the s^2 .
 - Labelled as “part” correlation in SPSS output

• Residual analysis

- A way to test key assumptions.

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Summary (MLR II)

• Interactions

- A way to model (rather than ignore) interactions between IVs.

• Analysis of change

- Use hierarchical MLR to “partial out” baseline scores in Step 1 in order to use IVs in Step 2 to predict changes over time.

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Questions



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MLR II Quiz – Practice question 1

In an MLR, the r between the two IVs is 1. Therefore, R will equal the r between one of the IVs and the DV.

[Hint: Draw a Venn Diagram.]

- True
- False

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MLR II Quiz – Practice question 2

In a MLR, if the two IVs are correlated with the DV and the two IVs are correlated with one another, the r_p s will be _____ in magnitude than the r s:

[Hint: Draw a Venn Diagram.]

- Equal
- Smaller
- Larger
- Impossible to tell

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**MLR II Quiz –
Practice question 3**

In MLR, the unique variance in the DV explained by a particular IV is estimated by its:

- Zero-order correlation squared (r^2)
- Multiple correlation coefficient squared (R^2)
- Semi-partial correlation squared (s^2)

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**MLR II Quiz –
Practice question 4**

Interaction effects can be tested in MLR by using IVs that represent:

- Cross-products between the IVs and DV
- Cross-products of IVs
- Semi-partial correlations squared (s^2)

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**MLR II Quiz –
Practice question 5**

A researcher wants to assess the extent to which social support from group members can explain changes in participants' mental health (MH) from the beginning to the end of an intervention program. What MLR design could be used?

- Hierarchical with pre-MH in Step 1
- Hierarchical with cross-products of IVs in Step 2

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References

- Allen, P. & Bennett, K. (2008). *SPSS for the health and behavioural sciences*. South Melbourne, Victoria, Australia: Thomson.
- Francis, G. (2007). *Introduction to SPSS for Windows: v. 15.0 and 14.0 with Notes for Studentware* (5th ed.). Sydney: Pearson Education.
- Howell, D. C. (2010). *Statistical methods for psychology* (7th ed.). Belmont, CA: Wadsworth.

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