psyc3010 lecture 13

This week:

1) PSYC3010 - overview
2) SECATs
3) Discussion of exam and distribution of practice exam
4) A bit on logistic regression
5) Interconnections between ANOVA and regression
Howell ch 16 p. 604-617

last week: mixed anova

Exam consult

- Please post and answer ?s in the discussion forum (which I will also monitor periodically)
- Consult times for me for the exam will be:
  - Monday 20 June 4-5pm
  - Friday 17 June 8-10am
  - Monday 13 June 1-3pm
  - Monday 6 June 3-4pm
  - Or by appointment
(1) what have we “added” in 3010 from 2010?

course overview

PSYC2010
- designs involving one factor or one predictor

PSYC3010
- designs involving multiple factors, predictors, or categorical variables
PSYC2010
- one-way between-subjects ANOVA
- one-way within-subjects ANOVA

PSYC3010
- factorial ANOVA
- between-subjects
  - 2-way
  - 3-way
- within-subjects
- mixed
- blocking (and ANCOVA)

PSYC2010
- bivariate correlation and regression

PSYC3010
multiple regression
- standard
- hierarchical
  - as control technique
  - assessing mediation
  - assessing moderation
PSYC3010 learning objectives

1. Generate research designs for questions involving multiple IVs / predictors, based on methodological and practical considerations.
2. Identify the statistical analyses that are appropriate for research designs involving multiple IVs / predictors.
3. Identify the key terms and conceptual principles relevant to statistical techniques involving multiple IVs / predictors.
4. Plan and execute (omnibus and follow-up) tests in statistical analyses involving multiple IVs / predictors.
5. Interpret results from these statistical analyses, identifying the implications of the results for hypotheses and research questions.
6. Report and discuss the results of these analyses, following standard conventions in Psychology.
7. Use your statistics knowledge to develop and enrich your work as a psychologist.

The purpose of statistics

- To understand the shape of the data
- To understand meaningful questions and assess meaningless ranting
  - “Women mature faster than men” “Men are stronger”
    - What’s the standard deviation? Is the difference reliable – Is it even going to be significant in the population?
    - What’s the effect size? What portion of the variance in the data does gender account for?
    - What are other factors associated with gender to control for (e.g., via ANCOVA)? [ANOVA is not causation!]
    - What other factors might moderate this effect? (interactions!)
The purpose of statistics

- Meaningful ?s and meaningless ranting
  - The wealthier you are, the happier you are!
    - Is that relationship reliable, is it significant in the population?
    - What is the effect size?
    - What other factors might need to be controlled for? [Correlation is not causation!]
    - What other factors might moderate this effect? (interactions!)
    - Is this really a linear effect?
- To read psych articles, need to know statistics – now you can read most & understand them
- more broadly, it's difficult to understand human variability meaningfully without understanding what variability and differences are and are not.

when do you use which analysis?

Need to consider the type of variables: independent (predictor) and dependent (criterion).

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Criterion</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorical</td>
<td>Continuous</td>
<td>ANOVA; MR</td>
</tr>
<tr>
<td>Categorical &amp; Continuous</td>
<td>Continuous</td>
<td>MR</td>
</tr>
<tr>
<td>Continuous</td>
<td>Continuous</td>
<td>MR</td>
</tr>
<tr>
<td>Continuous</td>
<td>Categorical</td>
<td>Logistic Regression</td>
</tr>
<tr>
<td>Categorical</td>
<td>Categorical</td>
<td>Log-linear Analysis</td>
</tr>
</tbody>
</table>
The multivariate universe:

- Before 3010:
  - Single explanations
  - Barely grasp difference between correlations and group differences
  - Tendency to rely too much on p-values

- After 3010:
  - Multiple explanations
  - Explanations that interact, or are inter-related
  - Variables considered jointly so you can see interactions and inter-relationships explain more than considering each alone
  - Strong understanding of correlations and group differences
  - Understanding key idea of effect sizes

(2) SETCs

Knowing artists, you think you know all about Prima Donnas: boy!, just wait till you hear scientists get up and sing.

-- W. H. Auden
(3) exam review: content, structure, & study tips

content of exam

→ primarily assesses conceptual material from lectures
  ▪ moving between research questions, design, hypotheses, and analytic choices
  ▪ partitioning variance (systematic and error)
  ▪ structural models ($X_{ij} = \ldots$)
  ▪ steps in analysis (omnibus and follow-up tests)
  ▪ key terms and principles in analysis
  ▪ interpretation of statistics
    – description of results (e.g., $F$ and $p$ values provided)
    – no SPSS output
  ▪ calculating degrees of freedom
structure of exam

- 50 multiple-choice questions
  - 1 mark each
  - content spread across Lectures 1 → 12

- 10 mins perusal + 2 hours working time

- formula sheet included
  - does not include DF calculations
  - Posted on Blackboard now

study resources on Blackboard

- recordings from all lectures
- slides from all lectures
- review notes for all lectures
  - key concepts and principles that you should know from each lecture

- practice exam questions
- tips for answering multiple-choice questions on a closed-book test
how to study for the exam I

revise lecture content (strategically…)

- go over lecture notes and listen to lecture recordings
- use the Review Notes to work out which principles and concepts you must understand and memorise
  - dot-points in Review Notes are listed in the same order as the concepts and principles in the lecture
- tutorial notes / textbook readings may clarify things…
- …but if you understand everything in the lecture slides, don’t worry about the tutorial / textbook content

how to study for the exam II

be prepared for the exam questions

- the exam questions will ask you to apply your knowledge from the lectures
- it is very important to complete the practice questions
  - PDFs for ANOVA and MR and ANCOVA
  - PDF for practice exam
  - Practice quizzes reopened online – why not keep going until you get them all right?
- it may also be useful to look at the tips for multiple-choice questions on a closed-book exam
important logistical details

- what you are allowed to bring to the exam:
  - non-programmable calculator (be aware of need to have approved model / sticker)
  - Unmarked non-electronic dictionary (you know, a book)

- check with UQ Central Examinations for list of things you are not allowed to bring in

- double-check the exam date / time / venue

- arrive at least 15 minutes before the exam

- be sure to have your ID card at the exam

Practice exam

- More practice MC questions
- Answers may be discussed in the PSYC3010 forum
- You are also welcome to attend Winnifred’s consult (times listed last slide)
(4) A bit on logistic regression

Multiple regression = continuous IVs and DVs, each normally distributed. We fit the data with a linear model – the straight line minimising the discrepancy between Y and Y hat.

![Graph showing the relationship between number of social events attended and life satisfaction. The graph includes a scatter plot with a linear trend line.]
Logistic regression = continuous IVs and categorical (0, 1) DV. Obviously (a) Y is not normally distributed and (b) a straight line fits this data poorly.

Accordingly we fit the data with a logistic model – the S-shape curve (a.k.a., sigmoidal curve) that best predicts whether an observation will be in one group (0) versus another (1).
Conceptual similarities:
Interpreting logistic R2 and R2 change

- In SPSS for logistic regression, you get R2 estimates labelled Cox & Snell R2 and Nagelkerke R2
  - These are two ways of understanding the “variance” in dichotomous (0, 1) DVs
  - No convention exists regarding which to report - C&S is the more conservative one, and Nagelkerke is more liberal – at the moment Nagelkerke R2 is more common.

- Hierarchical logistic regression can be performed
  - SPSS will output C&S and N R2 for each model but you need to subtract the later R2 from earlier to get R2 change / block

- R2 and R2 change are tested with chi-square (χ²) tests, not F-tests, but structure of write-up = identical
- Both X2 for model and for block are reported,
- R2 change must be calculated by hand from the output.25

Logistic Regression
Block 0: Beginning Block

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>S.E.</td>
<td>Wald</td>
<td>df</td>
<td>Sig</td>
<td>Exp(B)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.35</td>
<td>1.43</td>
<td>2.87</td>
<td>1</td>
<td>1.102</td>
</tr>
</tbody>
</table>

Block 1: Method = Enter

<table>
<thead>
<tr>
<th>Omnibus Tests of Model Coefficients</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square</td>
<td>df</td>
<td>Sig</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 Block</td>
<td>.856</td>
<td>2</td>
<td>.856</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>.866</td>
<td>2</td>
<td>.852</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Model Summary

<table>
<thead>
<tr>
<th>-2 Log Likelihood</th>
<th>Cox &amp; Snell R²</th>
<th>Nagelkerke R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>269.553a</td>
<td>.004</td>
</tr>
</tbody>
</table>

*Estimation terminated at iteration number 3 because parameter estimates changed by less than .001.

Variables in the Equation

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>S.E.</td>
<td>Wald</td>
<td>df</td>
<td>Sig</td>
<td>Exp(B)</td>
</tr>
<tr>
<td>c_age</td>
<td>-0.026</td>
<td>0.034</td>
<td>0.613</td>
<td>1</td>
<td>0.434</td>
</tr>
<tr>
<td>ec_women</td>
<td>-0.171</td>
<td>0.313</td>
<td>0.298</td>
<td>1</td>
<td>0.585</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.118</td>
<td>0.290</td>
<td>2.04</td>
<td>1</td>
<td>0.651</td>
</tr>
</tbody>
</table>

*Variable(s) entered on step 1: c_age, ec_women.

E.g. output and write-up

*A hierarchical logistic regression was conducted predicting whether or not participants took political action from demographic factors (Block 1) and attitude strength (Block 2). Table 1 describes the means, standard deviations, and intercorrelations. The entry of the demographics did not increase the variance accounted for, Nagelkerke R² = .01, χ² (2) = 0.86, p = .652 [snip]*
**E.g. output and write-up**

However, the entry of attitude strength in Block 2, significantly increased the variance accounted for, Nagelkerke $R^2$ change = .09, $X^2 (1) = 14.48, p < .001$. The final model accounted for only 10% of the variance in action however, $X^2 (3) = 15.33, p = .002$.

Note: the difference between 2LL in this model (255.078) and the first model (269.553) equals the chi-square value (14.475). Some reviewers prefer reporting 2LL over $R^2$.
Interpreting logistic coefficients

- Error = still deviations from the (s-shaped) line but now involve misclassification (e.g., predicted dead when is in fact alive) – instead of being normally distributed, errors also trend towards 0,1 distribution
- Instead of describing and reporting unstandardised coefficients, report Exp(B). This coefficient is tested with a Wald test not a t-test, but structure of write-up is same.
- Exp(B) coefficients don’t describe the 1 unit change in DV given 1 unit change in IV – they describe change in odds of being (1) compared to (0) for every unit increase in IV
  - Exp(B) = 1.00 – no change in likelihood of dead within 5 years for every 1 more social events
  - Exp(B) = 2.50 – likelihood of being dead within 5 years increases by 2.5 times (or increases by 250%) for every 1 more social events attended
  - Exp(B) = .80 – likelihood of death within 5 years increases by .8 times (but much more useful to say decreases by 20% [1-.8 = .2]) for every 1 more social events attended
A hierarchical logistic regression was conducted predicting whether or not participants took political action from demographic factors (Block 1) and attitude strength (Block 2). Table 1 describes the means, standard deviations, and intercorrelations. The entry of the demographics did not increase the variance accounted for, Nagelkerke $R^2 = .01$, $X^2 (2) = 0.86$, $p = .652$, and inspection of the coefficients revealed that neither age nor gender was significantly linked to action, Wald tests $< .30$, $p > .584$.

However, the entry of attitude strength in Block 2, significantly increased the variance accounted for, Nagelkerke $R^2$ change = .09, $X^2 (1) = 14.48$, $p < .001$. Specifically, on a scale from 0 to 5, every additional unit of attitude strength increased the likelihood of political action by 150%, $Exp(B) = 1.50$, $Wald = 13.44$, $p < .001$.

The final model accounted for only 10% of the variance in action however, $X^2 (3) = 15.33$, $p = .002$. 
Logistic regression is seen quite often, e.g.:
- clinical psychology (what factors predict becoming schizophrenic, recurrence of depression?)
- social (predict attending rally, getting divorced?)
- org psych (predict quitting the firm / being promoted?)
- Occasionally other statistics are reported but the above would serve in a journal article at the moment.
- Also can have multiple categories on DV
  - Use multinomial logistic regression
- So worth knowing
- Field spells it all out rather nicely and goes thru SPSS
- Covered in Howell section 15.14 (5th & 6th ed)
- But not assessed on exam!
- Also note: Log linear analysis is in Howell chpt 17 but we won't get around to covering this (as psychs you will come across logistic regression far more frequently)

(5) Interconnections between ANOVA and regression
experimental vs. correlational research

this is what many will tell you about the differences between anova vs correlational designs:

- **Anova designs**
  - the only research strategy in which causation can be inferred
  - the factor can be said to "cause" changes in DV
  - this is because the IV is manipulated

- **correlational research**
  - can not be used to infer causality
  - this is because variables are not manipulated -- just measured
experimental vs. correlational research

this is misleading because:

- it is confuses research methodology (PSYC3042) with statistical methodology (PSYC3010), and it assumes that the benefits of experimental research transfer automatically to anova
- the differences between experimental and correlational research involve random assignment to levels of IV vs observation of natural / measured levels of IV
- These have NOTHING to do with the differences between anova and regression, which involve partitioning variance between factors and within versus between a regression line and observations
- ANOVA can be carried out statistically with regression analyses; t-tests can be carried out with correlations
- All of these statistical techniques are generalisations of one underlying model, the general linear model (GLM),

The General Linear Model

What is it?

\[ X_{ijk} = \mu + \alpha_j + \beta_k + \alpha\beta_{jk} + e_{ijk} \]
\[ X_{ij} = \mu + \alpha_j + \pi_i + e_{ij} \]
\[ Y = b_1X + b_2Z + b_3XZ + c + e \]
The General Linear Model

*What is it?*

→ a system of linear equations which can be used to model data
← quite similar to the T1000:

- powerful!
- versatile!
- can execute a range of operations!
- can take on a variety of appearances!
- provides the basis for just about every parametric statistical test we know  (OK, weak link there...)

Read Cronbach, 1968 for more
magic tricks!

It is fairly easy to show that:

1. a t-test is a correlation
2. factorial ANOVA is a standard regression problem
3. ANCOVA is a hierarchical regression problem
4. interactions in ANOVA are identical to those in MMR

---

correlation and the t-test

- you may have heard of a point-biserial correlation (Howell p. 297-305)
- this is a special case of correlation where one of the variables is dichotomous (e.g., gender) and the other is continuous (e.g., height)
- the other name for a point-biserial correlation is an independent samples t-test
Females | Males  
---|---
150 | 165  
160 | 170  
165 | 180  
155 | 175  

Heights of males and females – this is how we are used to seeing the data laid out when we are doing hand calculations for t-test.

but we know that SPSS would prefer that we lay the data out like this

hmm...looks familiar...

<table>
<thead>
<tr>
<th>Gender</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>150</td>
</tr>
<tr>
<td>1</td>
<td>160</td>
</tr>
<tr>
<td>1</td>
<td>165</td>
</tr>
<tr>
<td>1</td>
<td>155</td>
</tr>
<tr>
<td>2</td>
<td>165</td>
</tr>
<tr>
<td>2</td>
<td>170</td>
</tr>
<tr>
<td>2</td>
<td>180</td>
</tr>
<tr>
<td>2</td>
<td>175</td>
</tr>
</tbody>
</table>

so let’s run our t-test...

Independent Samples Test

<table>
<thead>
<tr>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>HEIGHT</td>
<td>Equal variances assumed</td>
</tr>
<tr>
<td>HEIGHT</td>
<td>Equal variances not assumed</td>
</tr>
</tbody>
</table>

\[ t(6) = 3.29, \ p = .017 \]
now run as a correlation…
(just as if we had two continuous variables)

<table>
<thead>
<tr>
<th></th>
<th>GENDER</th>
<th>HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENDER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>1</td>
<td>.802*</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.</td>
<td>.017</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HEIGHT</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>.802*</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.017</td>
<td>.</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).

\[ r = .802, p = .017, r^2 = .643 \]

\[ \text{p value is the same as in t-test} \]

re-run as an anova…
(to get estimates of effect size)

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>450.000</td>
<td>1</td>
<td>450.000</td>
<td>10.800</td>
<td>.017</td>
<td>.643</td>
</tr>
<tr>
<td>Intercept</td>
<td>217800.000</td>
<td>1</td>
<td>217800.000</td>
<td>5227.200</td>
<td>.000</td>
<td>.999</td>
</tr>
<tr>
<td>GENDER</td>
<td>450.000</td>
<td>1</td>
<td>450.000</td>
<td>10.800</td>
<td>.017</td>
<td>.643</td>
</tr>
<tr>
<td>Error</td>
<td>250.000</td>
<td>6</td>
<td>41.667</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>218500.000</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>700.000</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = .643 \text{ (Adjusted } R^2 = .583) \]

\[ F(1,6) = 10.8, p = .017, \eta^2 = .643 \]

\[ \Rightarrow \text{p value is again the same} \]

\[ \Rightarrow \text{partial } \eta^2 = r^2 \text{ (from previous slide)} \]

\[ \Rightarrow F \text{ (i.e., 10.8) = } t^2 \text{ (i.e., 3.292)} \]
now run as a regression…
(just for the sake of comparison)

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.802*</td>
<td>.643</td>
<td>.583</td>
<td>6.45497</td>
</tr>
</tbody>
</table>

R\(^2 = \) partial \( \eta^2 = r^2 \)

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>450.000</td>
<td>1</td>
<td>450.000</td>
<td>10.800</td>
<td>.017*</td>
</tr>
<tr>
<td></td>
<td>250.000</td>
<td>6</td>
<td>41.667</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>700.000</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F and p are the same...

\( R^2 = .643, F(1,6) = 10.8, p = .017 \)

---

an additional slide to consolidate structural models

First to help interpretation re-run MR using dummy coding (female = 1 male = 0) Can use structural model to calc means:

<table>
<thead>
<tr>
<th>gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>4</td>
<td>172.50</td>
<td>6.45497</td>
<td>3.22749</td>
</tr>
<tr>
<td>female</td>
<td>4</td>
<td>157.50</td>
<td>6.45497</td>
<td>3.22749</td>
</tr>
</tbody>
</table>

Coefficients:

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent Variable: heighta.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
</tr>
<tr>
<td></td>
<td>gender</td>
</tr>
</tbody>
</table>

From t-test
From regress

\( Y_{\text{hat}} = a + B_1X_1 \)
So, for men (coded as zero), \( Y_{\text{hat}} = 172.50 - (15.00*0) = 172.50 \)
And for women (coded as one), \( Y_{\text{hat}} = 172.50 - (15.00*1) = 157.50 \)
explanation

- A t-test, or an ANOVA between two groups, is just a special case of correlation,
  - which in turn is just a special case of regression,
  - which is a representation of the General Linear Model.
- SPSS did the same* thing in all four analyses – it just presented the output in different ways.

*(strictly speaking, bivariate correlations and t-tests are not executions of the GLM – they are calculated using 'shortcuts' that achieve the same basic results)

hierarchical regression and ancova

- In ANCOVA our goal was to remove the effects of a covariate before examining our treatment effect.
- In hierarchical regression, the idea was to examine the contribution of a set of variables at step 2 after accounting for prediction at step 1.
  - As it turns out, both are basically doing the same thing!
let’s go back to our height data – and include *age* as a covariate:

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>150</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>160</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>165</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>155</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>165</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>170</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>180</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>175</td>
</tr>
</tbody>
</table>

data is laid out how we would for an ancova or a hierarchical regression

---

**first run as an ancova …**

Tests of Between-Subjects Effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>606.250</td>
<td>2</td>
<td>303.125</td>
<td>16.167</td>
<td>.007</td>
<td>.866</td>
</tr>
<tr>
<td>Intercept</td>
<td>47.690</td>
<td>1</td>
<td>47.690</td>
<td>2.543</td>
<td>.172</td>
<td>.337</td>
</tr>
<tr>
<td>AGE</td>
<td>156.250</td>
<td>1</td>
<td>156.250</td>
<td>8.333</td>
<td>.034</td>
<td>.025</td>
</tr>
<tr>
<td>GENDER</td>
<td>450.000</td>
<td>1</td>
<td>450.000</td>
<td>24.000</td>
<td>.004</td>
<td>.828</td>
</tr>
<tr>
<td>Error</td>
<td>93.750</td>
<td>5</td>
<td>18.750</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>218500.000</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>700.000</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* R Squared = .866 (Adjusted R Squared = .812)

for gender, $F(1,5) = 24.00$, $p = .004$

this is the effect after controlling for age
now run as hierarchical regression...

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Change Statistics</th>
<th>R Square Change</th>
<th>F Change</th>
<th>df1</th>
<th>df2</th>
<th>Sig. F Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>.93</td>
<td>.966</td>
<td>.43</td>
<td>.724</td>
<td>24.00</td>
<td>1</td>
<td>8</td>
<td>.004</td>
</tr>
</tbody>
</table>

*a. Predictors: (Constant), AGE  
*b. Predictors: (Constant), AGE, GENDER  

\[ F_{ch}(1, 8) = 24.00, \ p = .004 \]

this is the effect after controlling for age

Minor diffs in output

there are some minor differences in presentation:

- in our ancova we are given \[ \eta^2_p = .828 \] but in regression the \[ R^2ch \] was .643
- \[ \eta^2_p \] actually corresponds to the squared partial correlation for gender \[ .91^2 = .828 \]
Minor diffs in output

– in our ancova the test for age is given as $F(1,5) = 8.33, p = .034$
– this actually corresponds to the test of the coefficient for age in the full model at step 2:
  • *remember* $t^2 = F (2.887^2 = 8.33)$

<table>
<thead>
<tr>
<th>Model</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Partial</td>
</tr>
<tr>
<td>1</td>
<td>(Constant)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AGE</td>
<td>.472</td>
<td>.725</td>
<td>.496</td>
</tr>
<tr>
<td>2</td>
<td>(Constant)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AGE</td>
<td>.472</td>
<td>1.313</td>
<td>.237</td>
</tr>
<tr>
<td></td>
<td>GENDER</td>
<td>.802</td>
<td>2.887</td>
<td>.034</td>
</tr>
</tbody>
</table>

* a. Dependent Variable: HEIGHT

explanation

- ancova and hierarchical regression achieve the same broad purpose
- some minor differences in the output simply reflect defaults which have been programmed into SPSS
  - e.g., as effect sizes have only recently become emphasised for anova, these don’t line up as you would expect with the ones for regression, but the link is in there somewhere!
interactions – MMR vs anova

- testing interactions in anova and MMR look incredibly different
  - this is just because they have different histories
  - essentially they are doing the same thing

2 categorical variables

- going back to our height data, let’s say we wanted to examine the interaction between maternal diet and gender in the prediction of height…
  - factor A is gender (M/F)
  - factor B is maternal diet (healthy, unhealthy)
  (N = 16)
anova – the way we know…

Tests of Between-Subjects Effects
Dependent Variable: HEIGHT

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>435600.000</td>
<td>1</td>
<td>435600.000</td>
<td>11616.000</td>
<td>.000</td>
</tr>
<tr>
<td>GENDER</td>
<td>625.000</td>
<td>1</td>
<td>625.000</td>
<td>16.667</td>
<td>.002</td>
</tr>
<tr>
<td>DIET</td>
<td>100.000</td>
<td>1</td>
<td>100.000</td>
<td>2.667</td>
<td>.128</td>
</tr>
<tr>
<td>GENDER * DIET</td>
<td>225.000</td>
<td>2</td>
<td>225.000</td>
<td>8.000</td>
<td>.031</td>
</tr>
<tr>
<td>Error</td>
<td>450.000</td>
<td>12</td>
<td>37.500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1400.000</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>437000.000</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R Squared = .679 (Adjusted R Squared = .598)

\[ F (1,12) = 6.00, \ p = .031 \]

MMR…

- in our MMR lecture we talked briefly about categorical variables in MMR – they can get a bit tricky
- but with dichotomous variables it is dead easy
  - enter additive effects (gender and diet) at step 1
  - interaction term (gender*diet) at step 2….
### Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>R Square Change</th>
<th>F Change</th>
<th>df1</th>
<th>df2</th>
<th>Significance F Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.720</td>
<td>.518</td>
<td>.444</td>
<td>7.20571</td>
<td>.518</td>
<td>6.081</td>
<td>1</td>
<td>12</td>
<td>.031</td>
</tr>
<tr>
<td>2</td>
<td>.824</td>
<td>.679</td>
<td>.598</td>
<td>6.12372</td>
<td>.161</td>
<td>6.000</td>
<td>1</td>
<td>12</td>
<td>.031</td>
</tr>
</tbody>
</table>

*a. Predictors: (constant) DIET, GENDER...*  
*b. Predictors: (constant) DIET, GENDER, INT...*

\[ Fch (1,12) = 6.00, \ p = .031 \]

---

**implications**

- the GLM has been behind the scenes for just about all of the statistical methods examined in PSYC3010
- we stick to a lot of these conventions about when to use ANOVA instead of regression for practical reasons
- by understanding the common links through all these analyses we can be less rigid in our use of these tools
- here are some of the comparisons we can make
hypothesis testing

- in **ANOVA** we test the hypothesis that our manipulations have had a significant effect on our DV
  - $H_0$: $\mu_1 = \mu_2 = \mu_3$ — the null hypothesis — no differences among treatment means
  - $H_1$: the null hypothesis is false — the alternative hypothesis — there is at least one difference among treatment means

- in **regression** we test the hypothesis that our predictors are accounting for a significant amount of variance in our criterion
  - $H_0$: the relationship between the criterion and the set of predictors is zero
  - $H_1$: the relationship between the criterion and the set of predictors is **not** zero

variance partitioning

- in **ANOVA** we want to partition the total variance out into effects and error terms
  - **main effects** and **interactions** compared to **error**
  - the goal is to attribute a **significant** and **substantial** proportion of variance in our DV to our effects

- in **regression** we want to model our data by finding the line/plane of best fit, i.e., the one that minimises errors of prediction
  - the model can then be described in terms of **additive effects** and **interactions**, which are compared to **error**
  - the goal is to explain a **significant** and **substantial** proportion of variance in our criterion as possible
effect size

- in **ANOVA** we can quantify the amount of the total variance which each effect accounts for
  - eta-squared (*sample estimate*)
  - omega-squared (*population estimate*)

- in **regression** we can quantify the amount of variance that our model accounts for
  - $R^2$ (*sample estimate*)
  - $R^2$ adjusted (*population estimate*)
  - $sr^2$ (*importance of individual predictor*)

---

complex relationships

- in **ANOVA** we can test for 2-way or 3-way interactions (and beyond!)
  - the effect of factor A on the DV changes over levels of factor B
  - follow-up these with simple effects – i.e., examine the effect of A on the DV at each level of B

- in **regression** we can test for 2-way or 3-way interactions (and beyond!)
  - the relationship between X and Y varies over values of Z
  - follow-up these with simple slopes – i.e., examine the relationship between X and Y at high and low conditional values of Z
increasing power

- **in anova** we can employ a number of statistical and methodological techniques:
  - blocking on a concomitant factor
  - remove individual differences (i.e., use a within-subjects design)
  - include a covariate (i.e., use ancova)

- **in regression** we also have some similar techniques at our disposal:
  - partial the effect of another variable out first (i.e., use hierarchical regression - similar to ancova)
  - improve measurement (e.g., measure subjects with most reliable measures – i.e., higher alpha)

The multivariate universe:

- **Before 3010:**
  - Single explanations
  - Barely grasp difference between correlations and group differences
  - Tendency to rely too much on p-values

- **After 3010:**
  - Multiple explanations
  - Explanations that interact, or are inter-related
  - Variables considered jointly so you can see interactions and inter-relationships explain more than considering each alone
  - Strong understanding of correlations and group differences
  - Understanding key idea of effect sizes
**In the tutes**: No tutes!

**In future**:

Consult times for me for the exam will be:
- Monday 20 June 4-5pm
- Friday 17 June 8-10am
- Monday 13 June 1-3pm
- Monday 6 June 3-4pm
- Or by appointment

Every effort will be made to post the A2 marks online by Friday 18 June, 5pm, although this cannot be guaranteed

Assignment feedback sheets can be picked up from Winnifred by appointment

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Thank you!

Good luck on the exam