Overview of lecture

- What is a mixed (or split plot) design
- Partitioning the variability
- Pre-analysis checks
- Example ANOVA
- Reporting the Results
- Summary of ANOVA

Mixed or Split Plot Designs

- When there is more than one factor, we can have a mixed (or split plot) design:
  - One or more repeated measures
  - One or more between subjects measures
- The Mixed or Split Plot design combines features of both between groups and within subjects designs.
  - That is each level of factor A contains a different groups of randomly assigned subjects.
  - On the other hand, each level of factor B at any given level of factor A contains the same subjects
- No such thing as a one factor mixed design.

Partitioning the variance

- Partitioning the variance is done as for a standard ANOVA with small variations
- For the effects of interest
  - A between groups effect is estimated
  - A within subjects effect is estimated
  - An interaction effect is estimated
- For the error terms
  - A between subjects error is used for the between groups effect
  - Within subjects error term used for the within subjects effect
  - The within subjects error term is also used for the interaction effect since this includes a within subject component.

F ratios

- For the main effects and the interaction there are separate F ratios calculated

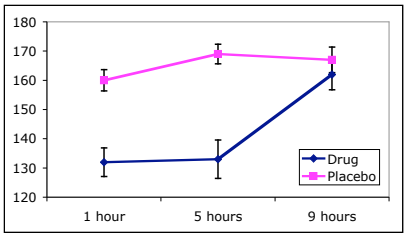
$$F_A = MS_A / MS_{S/A} \text{ with } (a-1) \ \& \ (a)(s-1)\ df$$

$$F_B = MS_B / MS_{BxS/A} \text{ with } (b-1) \ \& \ (a)(b-1)(s-1)\ df$$

$$F_{AB} = MS_{AB} / MS_{BxS/A} \text{ with } (a-1)(b-1) \ \& \ (a)(b-1)(s-1)\ df$$

Complete Example

- Assessing a drug treatment to reduce systolic blood pressure



Pre-analysis checks

- Homogeneity of Variance
  - For a mixed design it is necessary to check in a variety of different ways
    - Overall - Box's M
    - Within subjects - Mauchly's W
    - Between groups - Levene's test
- Normality
  - This can also be tested in a number of ways
- SPSS conduct's these tests.

Box's Test of Equality of Covariance Matrices

Homogeneity of variance

Box's M	4.189
F	.466
df1	6
df2	724.528
Sig.	.834

	Mauchly's W	Approx. Chi-Square	df	Sig.
TIME	.535	5.633	2	.060

Levene's Test	F	df1	df2	Sig.
Blood Pressure (1 hr)	.000	1	10	1.000
Blood Pressure (5 hrs)	4.675	1	10	.056
Blood Pressure (9 hrs)	.034	1	10	.858

Normality

		Skew	S.E.	z	p
Drug	1 hour	-1.369	0.845	-1.620	0.105
	5 hours	0.857	0.845	1.014	0.310
	9 hours	0.711	0.845	0.841	0.400
Placebo	1 hour	-0.313	0.845	-0.370	0.711
	5 hours	-0.668	0.845	-0.791	0.429
	9 hours	0.456	0.845	0.540	0.589

Anova Summary

Mixed Design (alias Split Plot)

Source of Variation	Sum of Squares	df	Mean Squares	F	p
A (Treatment)	4761.000	1	4761.000	83.820	0.0000
B (Time)	2198.000	2	1099.000	32.324	0.0000
AB	1554.000	2	777.000	22.853	0.0000
Between Error	568.000	10	56.800		
(Error BxS)	680.000	20	34.000		

Summary of omnibus F results

- A significant main effect of treatment
  - No further analyses required
- A significant main effect of time
  - Post hoc tests required (no a priori prediction)
- A significant interaction between treatment and time
  - Simple main effect analysis required

Main effect of time

- Post hoc tests - Tukey

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Comparisons Between Means for Selected Factor(s)
* = p<0.05 ** = p<0.01 *** = p<0.001 **** = p<0.0001

Tukey test
Comparison between levels of Time

1 hour      vs 5 hours        q =   2.97
1 hour      vs 9 hours        q =  10.99     ***
5 hours     vs 9 hours        q =   8.02     ***
```

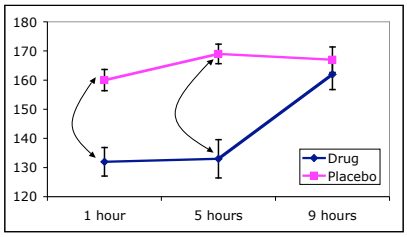

Simple main effects of Drug x Time interaction

Source of Variation	Sum of Squares	df	Mean Squares	F	p
Treatment at					
1 hour	2352.000	1	2352.000	56.538	0.0000
5 hours	3888.000	1	3888.000	93.462	0.0000
9 hours	75.000	1	75.000	1.803	0.1894
Error Term	1248.000	30	41.600		
Time at					
Drug	3484.000	2	1742.000	51.235	0.0000
Placebo	268.000	2	134.000	3.941	0.0361
Error Term	680.000	20	34.000		

Summary of simple main effects

- A significant simple main effect of Treatment at 1 hour
  - The blood pressure for the drug and placebo groups are significantly different at 1 hour
- A significant simple main effect of Treatment at 5 hours
  - The blood pressure for the drug and placebo groups are significantly different at 5 hours
- A non-significant simple main effect of Treatment at 9 hours
  - The blood pressure for the drug and placebo groups are not significantly different at 9 hours
- A significant simple main effect of Time at Drug
  - Post hoc tests required
- A significant simple main effect of Time at Placebo
  - Post hoc tests required

Simple main effects of Treatment



Post hoc analysis of simple main effects

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Comparison between levels of Time

   at level Drug

1 hour   vs 5 hours         q =     0.42
1 hour   vs 9 hours         q =    12.60     ***
5 hours  vs 9 hours         q =    12.18     ***

   at level Placebo

1 hour   vs 5 hours         q =     3.78     *
1 hour   vs 9 hours         q =     2.94
5 hours  vs 9 hours         q =     0.84
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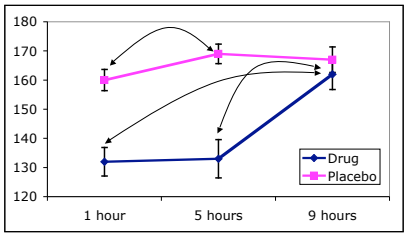
Simple main effects of Time



Reporting the results

"A two-way (2x3) mixed analysis of variance was conducted on systolic blood pressure. The independent variables included one between groups variable, *treatment*, with two levels (drug, placebo) and one within subject variable, *time*, with three levels (1 hour, 5 hours and 9 hours)"

	Time		
	1 hour	5 hours	9 hours
Drug	132 (6.573)	133 (8.832)	162 (7.014)
Placebo	160 (4.900)	169 (4.517)	167 (5.900)

Table 1: Means (and standard deviations) of blood pressure for the drug and placebo treatment groups for three times post adminstration

Reporting the results

- Report the main effects after the descriptive statistics

"There was a significant main effect of treatment ($F_{1,10}$=83.820, MSE=56.800, p<0.001). Overall the systolic blood pressure of the drug group (142.33) was less than that of the placebo group (165.33)."

"There was a significant main effect of time (F2,10=32.324, MSE=34.000, p<0.001). Post hoc tukey tests (at p≤0.05) were conducted to examine further the effect of time. The average systolic blood pressure at 9 hours (164.50) after adminstration of the treatment was significantly greater than at 5 hours (151.00) and at 1 hour (146.00). The latter were not significantly different."

Reporting the results

"There was a significant interaction between treatment and time ($F_{2,20}$=22.853, MSE=34.000, p<0.001; see Table 1). Simple main effects analysis demonstrated that the drug and placebo groups' systolic blood pressure was significantly different at 1 hour ($F_{1,30}$=56.538, MSE= 41.600, p<0.001) and 5 hours ($F_{1,30}$=93.462, MSE=41.600, p<0.001) but not at 9 hours ($F_{1,30}$=1.803, MSE= 41.600, p=.189). At both 1 hour and 5 hours the systolic blood pressure was greater for the placebo group than drug group"

"The simple main effect of time was significant for both the drug group ($F_{2,20}$=51.235, MSE=34.000, p<0.001) and the placebo group ($F_{2,20}$=3.941, MSE=34.000, p<0.05). Post hoc tukey tests (at p≤0.05) were conducted to explore further these effects. For the simple main effect of time for the drug group blood pressure was different between 1 hour and 9 hours and between 5 hours and 9 hours. However, blood pressure at 1 hour and 5 hours were not significantly different. Blood pressure was lower at 1 hour and 5 hours than at 9 hours for the drug group. For the placebo group, there was one significant difference between 1 hour and 5 hours with blood pressure at 5 hours being significantly greater"

Summary of ANOVA

- ANOVA is a parametric statistical technique for testing the differences between means.
- ANOVA can be used to analyse both single factor and multifactorial designs.
- Anova can be used to analyse differences in between ANOVA , within subjects and mixed designs.

Summary of ANOVA

- A number of assumptions are made by ANOVA that should be tested prior to analysis
- Significant results often require further analysis
- Both planned and unplanned comparisons can be conducted
- Interactions nearly always require further analysis
- A failure to find a significant result may be due to lack of statistical power