Chapter 9: How can I tell if scores differ between three or more groups? One-way independent measures ANOVA.

Full answers to study questions

1. Familywise error as a result of conducting multiple *t* tests.
    1.1. There are four categories, so six *t* tests would be needed.
        1. blonde vs. brown
        2. blonde vs. black
        3. blonde vs. auburn
        4. brown vs. black
        5. brown vs. auburn
        6. black vs. auburn
    1.2. There would be seven decade categories: 20s, 30s, 40s, 50s, 60s, 70s and 80s. Therefore 21 *t* tests would be needed.
        1. 20s vs. 30s
        2. 20s vs. 40s
        3. 20s vs. 50s
        4. 20s vs. 60s
        5. 20s vs. 70s
        6. 20s vs. 80s
        7. 30s vs. 40s
        8. 30s vs. 50s
        9. 30s vs. 60s
        10. 30s vs. 70s
        11. 30s vs. 80s
        12. 40s vs. 50s
        13. 40s vs. 60s
        14. 40s vs. 70s
        15. 40s vs. 80s
        16. 50s vs. 60s
        17. 50s vs. 70s
        18. 50s vs. 80s
        19. 60s vs. 70s

20. 60s vs. 80s
21. 70s vs. 80s

1.3. There are five categories, so 10 *t* tests would be needed.

1. plain vs. horizontal
2. plain vs. vertical
3. plain vs. diagonal
4. plain vs. checkered
5. horizontal vs. vertical
6. horizontal vs. diagonal
7. horizontal vs. checkered
8. vertical vs. diagonal
9. vertical vs. checkered
10. diagonal vs. checkered

2. The df for between, total and error are shown below. Full calculations are in the online resources.

2.1. $df_{between} = 3, df_{total} = 47, df_{error} = 44$

- $df_{between} = 4 - 1\ , df_{total} = 48 - 1\ , df_{error} = 47 - 3$

2.2. $df_{between} = 2, df_{total} = 74, df_{error} = 72$

- $df_{between} = 3 - 1\ , df_{total} = 75 - 1\ , df_{error} = 74 - 2$

2.3. $df_{between} = 4, df_{total} = 44, df_{error} = 40$

- $df_{between} = 5 - 1\ , df_{total} = 45 - 1\ , df_{error} = 44 - 4$

3. Results given in full and with interpretation of significance.

3.1. F (2, 36) = 8.6, $p < .001$, a significant finding.

3.2. F (3, 11) = 4.2, $p < .050$, a significant finding.

3.3. F (4, 24) = 4.9, $p < .010$, a significant finding.

Full answers for additional dataset

1. What method of analysis will you use to analyse this dataset?

   A one-way independent measures ANOVA. The IV is the food eaten, with three independent conditions: nothing, chocolate or chilli crisps. The DV is agreeableness.

2. Suggest a suitable hypothesis for this analysis.

   Agreeableness scores will differ significantly depending on the type of food eaten. (Note, this is a two-tailed hypothesis).

3. Calculate the *F* ratio and determine whether it is significant.

Note: The step numbers for calculations in the book chapter are repeated here.

	Nothing		**Chocolate**		**Chilli crisps**	
	Score (x)	Squared (x^2)	Score (x)	Squared (x^2)	Score (x)	Squared (x^2)
	6	36	12	144	2	4
	7	49	10	100	8	64
	8	64	8	64	6	36
	5	25	11	121	4	16
	4	16	12	144	12	144
	7	49	7	49	8	64
	9	81	9	81	5	25
	5	25	10	100	10	100
Totals (T)	51	345	79	803	55	453
Square of totals (T^2)	2601		6241		3025	
Mean ($\bar{x}$)	6.38		9.88		6.88	
Standard deviation (SD)	1.69		1.81		3.27	

6: $\sum T^2$ = 2601 + 6241 + 3025

$\sum T^2$ = 11867

7: $(\sum x)^2$ = $(51+79+55)^2$

$(\sum x)^2$ = 185^2

$(\sum x)^2$ = 34225

8: $\sum x^2$ = 345 + 803 + 453

$\sum x^2$ = 1601

<u>Stage One:</u> Calculate the Sums of Squares (SS)

9: $SS_{between} = \frac{11867}{8} - \frac{34225}{24}$

$SS_{between} = 1483.375 - 1426.042$

$SS_{between} = 57.333$

10: $SS_{total} = 1601 - \frac{34225}{24}$

$SS_{total} = 1601 - 1426.042$

$\text{SS}_{\text{total}} = 174.958$

11: $SS_{error} = 174.958 - 57.333$

$SS_{error} = 117.625$

Stage Two: Calculate the degrees of freedom (df)

12: $df_{between} = 3 - 1$

$df_{between} = 2$

13: $df_{total} = 24 - 1$

$df_{total} = 23$

14: $df_{error} = 23 - 2$

$df_{error} = 21$

Stage Three: Calculate the Mean Squares (MS)

15: $MS_{between} = {}^{57.333}/_{2}$

$MS_{between} = 28.667$

16: $MS_{error} = {}^{117.625}/_{21}$

$MS_{error} = 5.601$

Stage Four: Calculate the *F* ratio

17: $F = {}^{28.667}/_{5.601}$

$F = 5.118$

ANOVA summary table

Using the values you have calculated, complete this ANOVA summary table.

	Sums of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	F ratio
Between groups variance	57.3	2	28.7	5.1
Within groups error variance	117.6	21	5.6	
Total variance in the dataset	175.0	23		

4. Interpret and write up your findings using APA standards.

   There was a significant main effect of type of food eaten (F (2, 21) = 5.12, p < .050). Agreeableness was highest in the chocolate condition (M = 9.88, SD = 1.81), lower in the chilli crisps condition (M = 6.88, SD = 3.27) and slightly lower in the control condition (M = 6.38, SD = 1.69).

5. There is far more variability in one of the conditions than in the other two. Which condition has the greatest amount of error variance and suggest reasons why this might be? Suggest three measureable variables that might account for some of this error variance.

   There is far more variability in the chilli crisps condition, suggesting that agreeableness scores of participants in this condition were far more wide-ranging. There are a few reasons why this might be, but you could measure how much participants report liking crisps (those who dislike crisps might have lower scores), how spicy they tend to like their food (those who like very spicy food might have higher scores) or whether they are currently on a diet (being made to eat chocolate or crisps while on a diet may make people feel less agreeable).

Are p values enough? An optional exercise

$$\eta_p{}^2 = \frac{57.3}{57.3 + 117.6}$$

$$\eta_p{}^2 = \frac{57.3}{174.9}$$

$$\eta_p{}^2 = 0.3276$$

There was a significant main effect of type of food eaten (F (2, 21) = 5.12, $p < .050$; $\eta_p{}^2 = .33$) with a large effect size. Agreeableness was highest in the chocolate condition (M = 9.88, SD = 1.81), lower in the chilli crisps condition (M = 6.88, SD = 3.27) and slightly lower in the control condition (M = 6.38, SD = 1.69).