EDUC/PSY 6600

Research Design & Analysis I

Name:

Unit 4 Assignment

ANOVA without Repeated Measures

Please complete the following exercises. Feel free to work with classmates, but each student must turn in ***UNIQUE*** *work, not photocopies or identical replicates. When applicable, use* ***APA format*** *in communicating your results in text.* ***Show your work!*** *If any question involves any math at all, show your work. When it doubt, write it out. Always show more than you think you need.*

1) WRITE-UP - Textbook Problems

Cohen Chap		Exercises	Pts	Off
12	A	*5, 6, *7, 8	4	
	B	4, *5, 6, 14 *(14 use G*Power)*	4	
	C	1, 2, 3, 5	4	
13	A	*3, 4, *5	3	
	B	*3, 4, 8	4	
	C	1, 2, 4 *(exclude 1b)*	4	
14	A	2, 4, 6	3	
	B	7, *8	2	
	C	1, 4, 5	4	

2) SUMMARY – Supplementary Reading

	Fasting leptin and glucose in normal weight, over weight and obese men and women diabetes patients with and without clinical depression	Pts	Off
Half Page	Read the Unit 4 Journal Article on Canvas. Summarize any mention or use/abuse of the concepts in the above chapters.	5	

3) R SYNTAX – Section B & C: add to the skeleton R notebook and knit to .pdf & upload

Cohen Chap		Exercises	Pts	Off
12	B	4, *5, 6	3	
	C	1, 2, 3, 5	3	
13	C	1, 2, 4 *(no R for 1b)*	2	
14	B	7, *8	3	
	C	1, 4, 5	2	

Grading

		Earned	Possible
CORRECTNESS	*a subset of spot-checked items: must show work, especially items from back of book or done in class*		50
COMPLETENESS	*more than one item is missing or skipped: 25/50 roughly half the assignment is completed: 10/50*		50
			100

12 A *5. Calculate an F ratio - from summary stats

The **240 students** in a large introduction psychology class are scored on an introversion scale that they filled out in class, and then they are **divided equally into three groups** according to whether they sit near the front, middle, or back of the lecture hall. The means and standard deviations of the introversion scores for each group are as follows:

	Front	Middle	Back
M	28.7	34.3	37.2
SD	11.2	12.0	13.5

Calculate the F ratio**.**

Grand Mean

$$\bar{x}_G = \frac{\sum_{i=1}^{k} \bar{x}_i}{k}$$

Formula 12.7

$$MS_{BetGrp} = n\frac{\sum_{i=1}^{k} (\bar{x}_i - \bar{x}_G)^2}{k-1}$$

Formula 12.5B

$$MS_{WithGrp} = \frac{\sum_{i=1}^{k} s_i^2}{k}$$

Formula 12.7

$$F = \frac{MS_{BetGrp}}{MS_{WithGrp}}$$

Formula 12.4

$$df_{BetGrp} = k - 1$$
$$df_{WithGrp} = n_T - k$$

F (_____ , _____) = ___________

12 A 6. The effect on the F ratio - doubling standard deviation

Suppose the **standard deviations** in Exercise 5 were **twice as large**, as follows:

	Front	Middle	Back
SD	22.4	24.0	27.0

Calculate the F ratio and **compare** it to the F ratio you calculated for exercise 5.

F (_____ , _____) = ___________

What is the **effect** on the F ratio of doubling the standard deviation?

12 A *7. Calculate an F ratio, F critical value, & conclusion

A psychologist is studying the effects of various drugs on the speed of mental arithmetic. In an exploratory study, **32 subjects were divided equally into four drug conditions**, and each subject solves as many problems as he or she can in 10 minutes. The mean number of problems solved follows for each drug group, along with the standard deviations:

	Marijuana	Amphetamine	Valium	Alcohol
M	7	8	5	4
SD	3.25	3.95	3.16	2.07

a) Calculate the F ratio

Formula 12.7

$$MS_{BetGrp} = n\frac{\sum_{i=1}^{k}(\bar{x}_i - \bar{x}_G)^2}{k-1}$$

Grand Mean

$$\bar{x}_G = \frac{\sum_{i=1}^{k}\bar{x}_i}{k}$$

Formula 12.5B

$$MS_{WithGrp} = \frac{\sum_{i=1}^{k}s_i^2}{k}$$

Formula 12.4

$$df_{BetGrp} = k - 1$$

$$df_{WithGrp} = n_T - k$$

Formula 12.7

$$F = \frac{MS_{BetGrp}}{MS_{WithGrp}}$$

F (_____ , _____) = ___________

b) Find the critical F (alpha = .05) . (table A.7)

Fcv (_____ , _____) = ___________

c) What can you **conclude** with respect to the null hypothesis?

12 A 8. The effect on the F ratio - doubling total sample size

If the study in exercise 7 were repeated with a **total of 64 subjects**:

a) What would be the new value for calculated F?

F (_____ , _____) = ___________

b) How does the F ratio calculated in part a compare to the F calculated in exercise 7? What general rule relates changes in the F ratio to changes in sample size (when all samples are the same size and all else remains unchanged)?

c) What is the new critical F (alpha = .05)? (table A.7)

Fcv (_____ , _____) = ___________

12 B	4. one-way ANOVA from a raw dataset	Code: R notebook

A social psychologist wants to know how long people will wait before responding to cries for help from an unknown person and whether the gender or age of the person in need of help makes any difference. One at a time, subjects sit in a room waiting to be called for an experiment. After a few minutes they hear cries for help from the next room, which are actually on a tape recording. The cries are in either an adult male's, an adult female's, or a child's voice; **seven subjects are randomly assigned to each condition**. The dependent variable is the number of seconds from the time the cries begin until the subject gets up to investigate or help. (see data in book)

a) Calculate the F ratio. ← from R

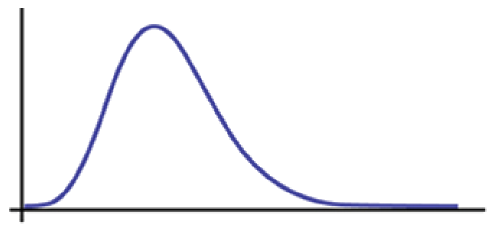
F (_____ , _____) = ___________

b) Find the critical F (alpha = .05) (table A.7)

F_{CV} (_____ , _____) = ___________

H_0 : ____

☐ *Provides evidence against the Null*
☐ *No evidence against the Null*



c) What is your statistical **conclusion**? (in APA format please)

d) Present the results of the ANOVA in a complete summary table. ← from R

	SS	df	MS	F	Sig
Between Groups (caller type)					
Within Groups (residual or error)					
Total					

e) Calculate eta squared using ***formula 12.10*** and compare it the one produced in R (ges or pes)

Formula 12.10

$$ordinary\ \eta^2 = \frac{SS_{effect}}{SS_{total}}$$

η^2=

☐ *Strong*
☐ *Medium*
☐ *Weak*

12	B	5. one-way ANOVA from a raw dataset	Code: R notebook

A psychologist is interested in the relationship between color of food and appetite. To explore this relationship, the researcher bakes small cookies with icing of one of **three different colors** (green, red, or blue). The researcher offers cookies to subjects while they are performing a boring task. Each subject is run individually under the same conditions, except for the color of the icing on the cookies that are available. **Six subjects are randomly assigned to each color**. The number of cookies consumed by each subject during the 30-minute session is shown in the following table: (see book)

a) Calculate the F ratio.

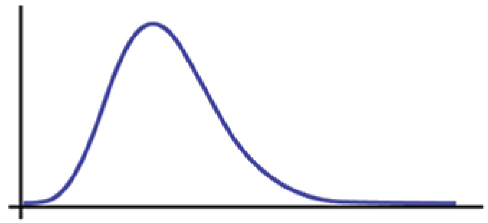
F (_____ , _____) = ___________

b) Find the critical F (alpha = .05) (table A.7)

F_{CV} (_____ , _____) = ___________

H_0 : ________________________________

☐ *Provides evidence against the Null*
☐ *No evidence against the Null*



c) What is your statistical **conclusion**? (in APA format please)

d) Present the results of the ANOVA in a summary table. ← from R

	SS	df	MS	F	Sig
Between Groups (icing color)					
Within Groups (residual or error)					
Total					

e) Why do we not discuss the **effect size** on this analysis?

12	B	6. one-way ANOVA – effect of larger mean values	Code: R notebook

Suppose the data in exercise 5 had turned out differently. In particular, suppose that the number of cookies eaten by the subjects in the green condition remains the same, but each subject in the red condition ate **10 more** cookies that in the previous data set, and each subject in the blue condition ate 20 more. (see modified data in book)

a) Calculate the F ratio.

F (_____ , _____) = ___________

b) Which part of the F ratio has **changed** from the previous exercise and which part has remained the **same**?

c) Put your results in a summary table to facilitate comparison with the results of #5 ← from R

	SS	df	MS	F	Sig
Between Groups (icing color)					
Within Groups (residual or error)					
Total					

d) Calculate **omega squared** with formula 12.12 and **adjusted eta squared** with formula 12.14.

Formula 12.12

$$est. \varpi^2 = \frac{SS_{BetGrp} - (k-1)MS_W}{SS_{total} + MS_W}$$

est. ω² =

Formula 12.10

$$ordinary\ \eta^2 = \frac{SS_{BetGrp}}{SS_{total}}$$

Formula 12.14

$$modified\ \eta^2 = \eta^2 \left(1 - \frac{1}{F}\right)$$

adj η² =

Are they the same? Explain.

12	B	14. Relationship between sample size and effect size

a) Approximately **how many subjects per group** are needed in a four-group experiment if f is expected to be .2 and power must be at least .77 for a .05 test? (hint: begin by assuming df_error will be very large)

G*Power	Selections	Inputs	Outputs
	Test Family		
	Statistical Test		
	Type of power analysis		

n_j =

b) **How many subjects per group** would be needed in part (a) if f were equal to .1? All else being equal, **what happens** to the number of subjects required **when f is cut in half**?

G*Power	Selections	Inputs	Outputs
	Test Family		
	Statistical Test		
	Type of power analysis		

n_j =

c) If you have three groups of eight subjects each and you want power to be at least .80 for a .05 test, approximately, **how large does f have to be**?

G*Power	Selections	Inputs	Outputs
	Test Family		
	Statistical Test		
	Type of power analysis		

f =

12	C	**1.Effect size & APA results**	**Code: R notebook**

Perform a one-way ANOVA to test whether the different **experimental conditions** had a significant effect on the **post quiz heart rate**.

Cells = M(SD)

	Easy (n = _______)	Moderate (n = _______)	Hard (n = _______)	Impossible (n = _______)
Post Quiz Heart Rate				

ANOVA's: F (______ , ______) = ____________ , p-value = ___________

Request descriptive statistics and an HOV test.

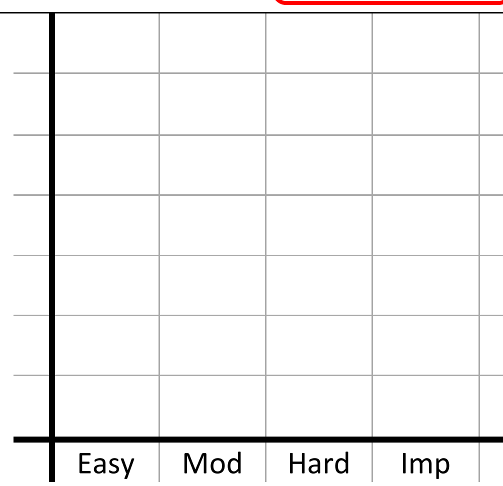
Levene's: F (______ , ______) = ____________ , p-value = ___________

~~**Calculate**~~ **Report the eta squared from your ANOVA output**

☐ *Strong* ☐ *Medium* ☐ *Weak*

η^2=

And present your results in APA style.



12	C	2.HOV assumption & APA results	Code: R notebook

Using **college major** as the independent variable, perform a one-way ANOVA to test for significant differences in both **mathquiz** and **statquiz**. Request descriptive statistics and an HOW test.

Cells = M(SD)

	Psychology (n = _______)	Premed (n = _______)	Biology (n = _______)	Sociology (n = _______)	Economics (n = _______)
Math Quiz					
Stat Quiz					

Math quiz

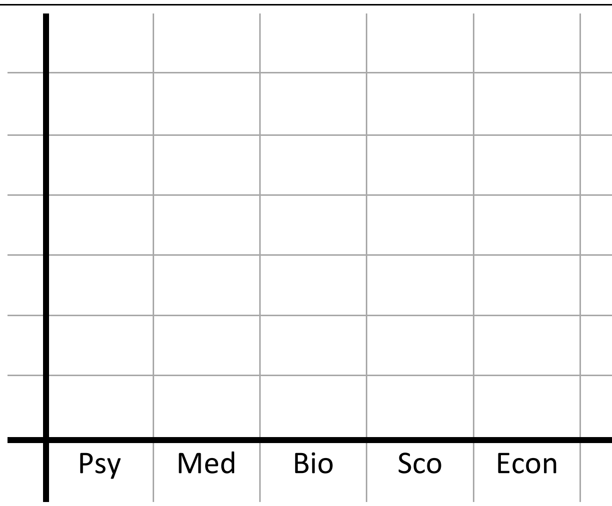
ANOVA's: F (___ , _____) = __________ ,

p-value = _________

Levene's: F (___ , _____) = __________ ,

p-value = _________

η^2=



Stat quiz

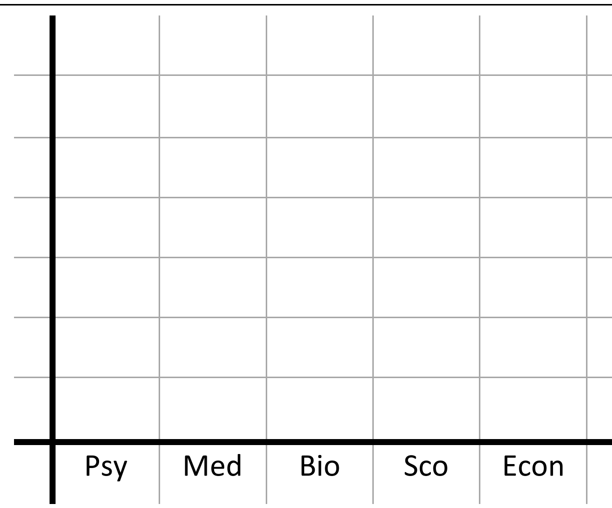
ANOVA's: F (___ , _____) = __________ ,

p-value = _________

Levene's: F (___ , _____) = __________ ,

p-value = _________

η^2=



Based on the **HOV test**, for which DV should you consider **performing an <u>alternative</u>** ANOVA test?

For whichever DV yield a **p value between .05 and .10,** report its results as a **trend**. For whichever DV yield a **p value less than .05**, calculate the corresponding value of **eta squared** (formula 12.10) and report the **ANOVA results**, along with the **means for the groups**, in **APA style.**

12	C	3. HOV assumption & APA results	Code: R notebook

Repeat exercise 2 after using **dplyr::filter()** to **eliminate** all of the psychology and premed students.

Math quiz	**Stat quiz**
ANOVA's: F (___ , _____) = __________ , **p-value = _________**	**ANOVA's: F (___ , _____) = __________ ,** **p-value = _________**
Levene's: F (___ , _____) = __________ , **p-value = _________**	**Levene's: F (___ , _____) = __________ ,** **p-value = _________**
η^2=	η^2=

Based on the **HOV test**, for which DV should you consider **performing an <u>alternative</u>** ANOVA test?

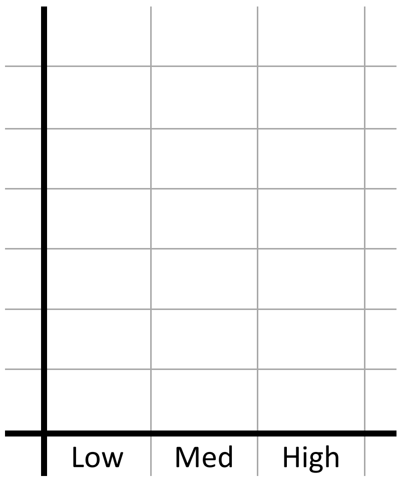
For whichever DV yield a **p value between .05 and .10,** report its results as a **trend**. For whichever DV yield a **p value less than .05**, calculate the corresponding value of **eta squared** (formula 12.10 or the R output ;) and report the **ANOVA results**, along with the **means for the groups**, in **APA style.**

12	C	5. ANOVA APA results	Code: R notebook

Use **dplyr::mutate() & case_when()** to create a grouping variable from phobia, such that group 1 contains those with phobia ratings of 0, 1, or 2; group 2 = 3 or 4; and group 3 = 5 or more (you might call the new variable **phob_group**. Then use **dplyr::mutate()** to create another new variable, **hr_diff**, that equals hr_pre minus hr_base. Perform a **one-way ANOVA** on hr_diff using phob_group as the factor. Request **descriptive** statistics.

Cells = M(SD)

	Low Phobia (n = ______)	Med Phobia (n = ______)	High Phobia (n = ______)
Hear Rate Difference			



ANOVA's: F (___ , _____) = __________ ,

p-value = _________

Levene's: F (___ , _____) = __________ ,

p-value = _________

η^2=

Report your **results in APA style**, including **means** of the three groups. Explain what this ANOVA **demonstrates**, in terms of the variables involved. (formula 12.10or the R output ;)

13	A	3. Pair-wise Post-hoc t tests

In exercise 12A5, the introversion means and standard deviations for students seated in three classroom locations (**n = 80 per group**) were as follows:

	Front	Middle	Back
M	28.7	34.3	37.2
SD	11.2	12.0	13.5

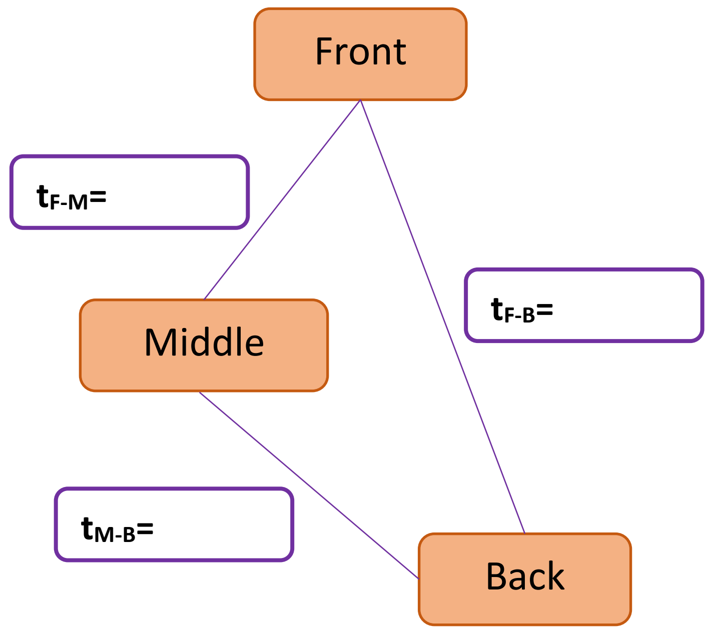
a) Use formula 13.4 to calculate a t value for each pair of means.

Formula 12.5B

$$MS_{WithGrp} = \frac{\sum_{i=1}^{k} s_i^2}{k}$$

Formula 13.4

$$t_{pair} = \frac{\bar{x}_i - \bar{x}_j}{\sqrt{\frac{2MS_w}{n}}}$$



b) Which of these t values exceed the critical t based on df_w, with alpha = .05? (table A.2)

Formula 12.4

$$df_{WithGrp} = n_T - k$$

t_{CV} (______) = ____________

13 A 4.Effect on Pair-wise Post-hoc t tests – 2x SD

Assume the **standard deviations** from exercise 3 were **doubled**.

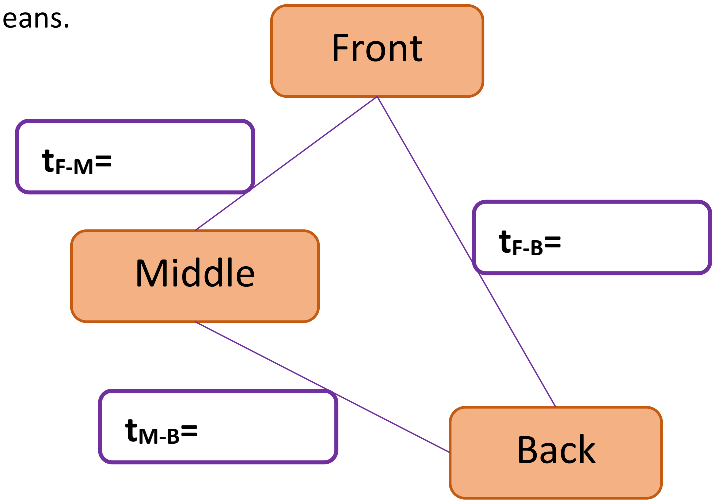
a) Recalculate the t value for each pair of means.

Formula 12.5B

$$MS_{WithGrp} = \frac{\sum_{i=1}^{k} s_i^2}{k}$$

Formula 13.4

$$t_{pair} = \frac{\bar{x}_i - \bar{x}_j}{\sqrt{\frac{2MS_w}{n}}}$$



b) Which of these t values NOW exceed the critical t?

c) What is the effect on the t value of **doubling the standard deviations**?

13 A 5.Effect on Pair-wise Post-hoc t tests – ¼ sample size

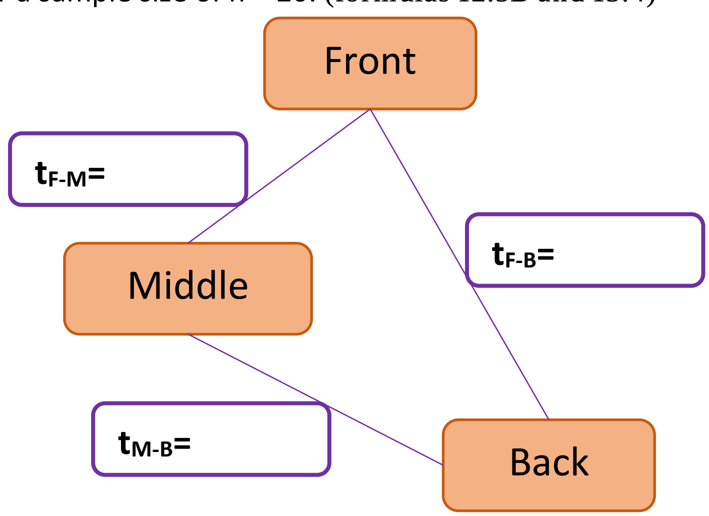
a) Recalculate the t values from exercise 3 for a sample size of n = 20. (formulas 12.5B and 13.4)

Formula 12.5B

$$MS_{WithGrp} = \frac{\sum_{i=1}^{k} s_i^2}{k}$$

Formula 13.4

$$t_{pair} = \frac{\bar{x}_i - \bar{x}_j}{\sqrt{\frac{2MS_w}{n}}}$$



b) What is the effect on the t value of **dividing the sample size by 4?**

13	B	3.Fisher's LSD & Tuekey's HSD corrections & Conf Intervals

In exercise 12A7, the following means and standard deviations were given as the hypothetical results of an experiment involving the effects of four different drugs (**n = 8 subjects per group**):

	Marijuana	Amphetamine	Valium	Alcohol
M	7	8	5	4
SD	3.25	3.95	3.16	2.07

a) Calculate Fisher's LSD (alpha = .05), whether or not it is permissible. (see page 3 for the MS_w)

Formula 12.4
$$df_{WithGrp} = n_T - k$$

Formula 13.7
$$LSD = t_{CV}\sqrt{\frac{2MS_w}{n}}$$

t$_{CV}$ (_____) = ___________

Fisher'S LSD =

b) Calculate Tukey's HSD (alpha = .05).

q$_{CV}$ (_____ , _____) = ___________

Formula 13.8
$$HSD = q_{CV}\sqrt{\frac{MS_w}{n}}$$

Tukey's HSD =

c) Use HSD to construct **95% Cis** for each pair of drug conditions.

Marijuana vs. Amphetamine = _________ , _________

Marijuana vs. Valium = _________ , _________

Marijuana vs. Alcohol = _________ , _________

Amphetamine vs. Valium = _________ , _________

Amphetamine vs. Alcohol = _________ , _________

Valium vs. Alcohol = _________ , _________

13	B	4.LSD & HSD – effect of doubling sample size

Recalculate Fisher's LSD and Tukey's HSD for the data in exercise 3, assuming that the number of **subjects per group was 16**. (formula 12.4, tables A.2 & A.11, formulas 13.7 & 13.8)

Formula 12.4

$$df_{WithGrp} = n_T - k$$

Formula 13.7

$$LSD = t_{CV}\sqrt{\frac{2MS_W}{n}}$$

tCV (______) = ____________

Formula 13.8

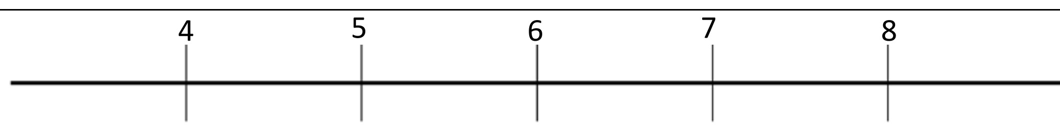
$$HSD = q_{CV}\sqrt{\frac{MS_W}{n}}$$

qCV (______ , ______) = ____________

Fisher's LSD =

Tukey's HSD =

a) What effect does **increasing the number of subjects** have on the size of LSD and HSD?



b) What conclusions can you draw from the LSD test?

c) Does the conclusion from Tukey's HSD differ?

d) Which test is recommended in the four-group case and why?

13	B	8. HSD with FIVE groups & modified LSD

In exercise 12B1, an experiment involving five different antidepressants yielded the following means and standard deviations:

	1	2	3	4	5
M	23	30	34	29	26
SD	6.5	7.2	7	5.8	6

a) Assuming that none of the original subjects were lost (i.e. n = 15), calculate Tukey's HSD for this experiment.

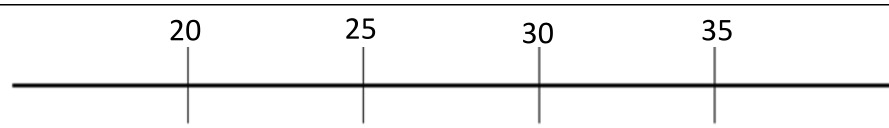
Formula 12.4
$$df_{WithGrp} = n_T - k$$

Formula 12.5B
$$MS_{WithGrp} = \frac{\sum_{i=1}^{k} s_i^2}{k}$$

Formula 13.8
$$HSD = q_{CV}\sqrt{\frac{MS_w}{n}}$$

q_{CV} (_____ , _____) = ___________

Tukey's HSD =



b) Which pairs of means differ significantly?

e) Calculate the modified LSD. (pages 424-425)

q_{CV} (_____ , _____) = ___________

Formula 12.4
$$df_{BetGrp} = k - 1$$
$$df_{WithGrp} = n_T - k$$

$$mod\ LSD = q_{CV}\sqrt{\frac{MS_w}{n}}$$

Modified Fisher's LSD =

Would using this test change your answer to part b?

13	C	1. LSD & Tukey post-hoc tests	Code: R notebook	*(exclude 1b)*

a) Redo the one-way ANOVA requested in Exercise #1 of the previous chapter selecting both LSD and Tukey as Post Hoc tests.

For postquiz heart rate, which pairs of experimental conditions differ significantly from each other, according to each test.

Fisher's LSD *(adjust = "none")*	**Tukey's HSD** *(adjust = "tukey")*

Can you justify using the results of the LSD test?

c) Perform a contrast to compare the "impossible" condition with the other three for postquiz heart rate

Contrast: t(_____) = _________, p = _______

How does the significance of this contrast compare to the one-way ANOVA?
Explain.

Looking at the means for the four conditions, design a contrast that you think would capture a large portion of the between-group variance.

13	C	2.post-hoc all tests vs. planned comparisons	Code: R notebook

a) Redo the one-way ANOVA requested in Exercise #2 of the previous chapter just for the **mathquiz** variable, TWICE: once with **Tukey** and once with **Bonferroni** as post hoc tests in each case.

b)
Why is it problematic to use HSD with major as the factor in this dataset?

Given the results of the post hoc tests, does the Tukey or Bonferroni test seem to have greater power when testing all possible pairs of means?

Tukey's HSD *(adjust = "tukey")*	**Bonferroni** *(adjust = "bon")*

c) Redo the one-way ANOVA requested in Exercise 2 of the previous chapter just for the **statquiz** variable, and request a **contrast** that compares the **average** of the biology and sociology majors to the average of the other three majors.

Contrast: t(___) = _________, p = _______

Would this contrast be significant if it had been planned?

- ☐ *Yes*
- ☐ *No*

Would this contrast be significant according to Scheffé's test? (formula 13.16)

$F = t^2$

F =

Formula 13.16 (1-way)
$F_s = (k-1)F_{cv}(k-1, n_T - k)$

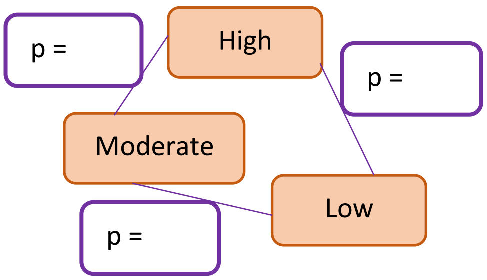
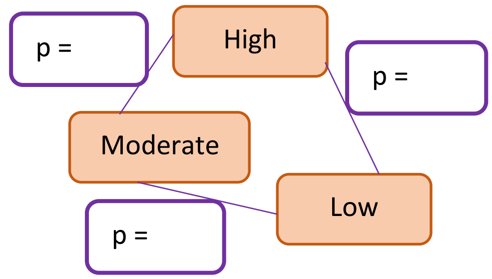
$F_{Scheffe}$ =

- ☐ *Yes*
- ☐ *No*

13	C	4. post-hoc all tests & contrasts	Code: R notebook

a) Perform a one-way ANOVA on the **pre-quiz anxiety** measurement (anx_pre) using **the grouping variable** (phob_group) you created in Exercise 5 of the previous chapter (based on phobia ratings). Select both LSD and Bonferroni as your post hoc tests.

Which pairs differ significantly for each test?

Fisher's LSD *(adjust = "none")*	**Bonferroni** *(adjust = "bon")*
	

b) Perform a **contrast** that compares students who had reported **low or moderate** phobia with those reporting **high** phobia.

Calculate the **effect size** for this contrast. *(hint: use formula 13.9 to find the harmonic mean of the 3 sample sizes (n_H = 31.80165) & then use formula 8.5 to find the effect size)*

Contrast: t(_____) = _________, p = _______

Formula 13.9

$$n_H = k \frac{1}{\sum_{i=1}^{k} {}^{1}/_{n_i}}$$

Formula 8.5

$$g = t\sqrt{\frac{2}{n}}$$

g =

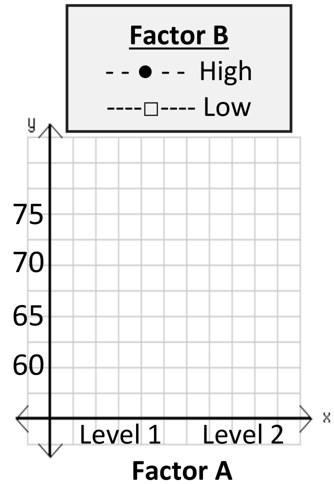
Is it small, medium, or large? *(Cohen's guide lines are on page 242)*

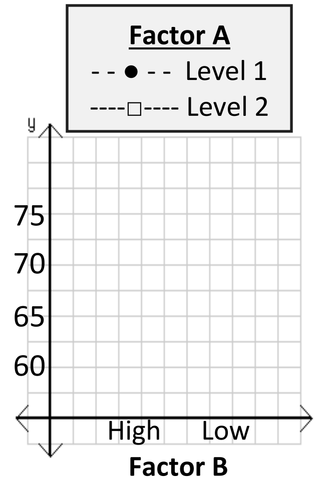
- ☐ *Strong*
- ☐ *Medium*
- ☐ *Weak*

14 A 2. Marginal Means & two-way effects from cell means

a) Graph the cell means in the following table, and find the marginal means
NOTE: There are two ways to plot the means, depending on which factor you use for the x-axis

		Factor A		
		Level 1	**Level 2**	
Factor B	**High**	**75**	**70**	
	Low	**60**	**65**	





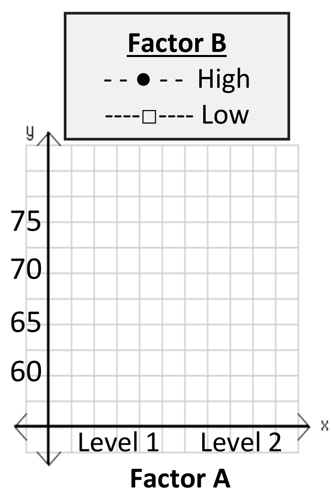
b) Which effects might be **significant**, and which **cannot** be significant?

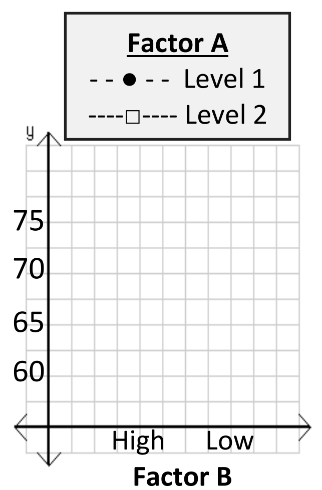
Main effect for Factor A	Main effect for Factor B	Interaction between factors A & B
☐ might be significant ☐ cannot be significant	☐ might be significant ☐ cannot be significant	☐ might be significant ☐ cannot be significant

14 A 4. Marginal Means & two-way effects from cell means

a) Graph the cell means in the following table, and find the marginal means

		Factor A		
		Level 1	**Level 2**	
Factor B	**High**	**75**	**70**	
	Low	**75**	**70**	





b) Which effects might be **significant**, and which **cannot** be significant?

Main effect for Factor A	Main effect for Factor B	Interaction between factors A & B
☐ might be significant ☐ cannot be significant	☐ might be significant ☐ cannot be significant	☐ might be significant ☐ cannot be significant

14	A	6. Two-way ANOVA from cell means & standard deviations

A researcher is studying the effects of both regular exercise and a vegetarian diet on resting heart rate. A 2 x 2 matrix was created to cross these two factors (Exercisers versus non-exercisers, and vegetarians versus non-vegetarians), and 10 subjects were found for each cell. The mean heart rates and standard deviations for each cell are as follows:

	exercisers	**Non-exercisers**
Vegetarians	M = 60 & SD = 15	M = 70 & SD = 18
Non-vegetarians	M = 65 & SD = 16	M = 75 & SD = 19

a) What is the value of **MS_w**? ("mean squared within")

Formula 12.5B

$$MS_W = \frac{\sum_{i=1}^{k} s_i^2}{k}$$

MS$_{with}$ =

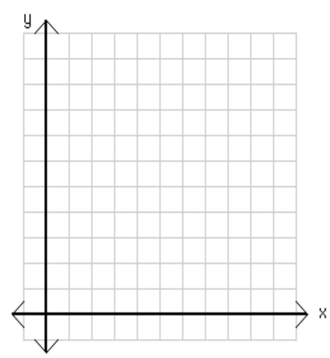
b) Calculate the **three F ratios**. (Hint: check to see if there is an interaction. If there is none, the calculation is simplified)

If no interaction...

$$MS_{row} = n_r \frac{\sum_{i=1}^{r}(\bar{x}_i - \bar{x}_G)^2}{r-1}$$

$$MS_{col} = n_c \frac{\sum_{i=1}^{c}(\bar{x}_i - \bar{x}_G)^2}{c-1}$$

$$MS_{inter} = 0$$



Formula 14.6

$$F_{row} = \frac{MS_{Row}}{MS_W}$$

$$F_{col} = \frac{MS_{Col}}{MS_W}$$

$$F_{inter} = \frac{MS_{inter}}{MS_W}$$

Formula 14.4

$$df_{row} = r - 1$$
$$df_{col} = c - 1$$
$$df_{inter} = (r-1)(c-1)$$
$$df_W = n_T - rc$$

F$_{activity}$ (__ , _____) = ___________

F$_{diet}$ (__ , _____) = ___________

F$_{interact}$ (__ , _____) = ___________

F$_{CV}$ (_____ , _____) = ___________

State your **conclusion**.

c) How large would these F ratios be if there were **40 subjects** per cell?

Formula 14.4
$$df_W = n_T - rc$$

If no interaction...

$$MS_{row} = n_r \frac{\sum_{i=1}^{r}(\bar{x}_i - \bar{x}_G)^2}{r-1}$$

$$MS_{col} = n_c \frac{\sum_{i=1}^{c}(\bar{x}_i - \bar{x}_G)^2}{c-1}$$

$$MS_{inter} = 0$$

Formula 14.6

$$F_{row} = \frac{MS_{Row}}{MS_W}$$

$$F_{col} = \frac{MS_{Col}}{MS_W}$$

$$F_{inter} = \frac{MS_{inter}}{MS_W}$$

$F_{activity}$ (__ , _____) = ___________

F_{diet} (__ , _____) = ___________

$F_{interact}$ (__ , _____) = ___________

Compare these values to the ones you calculated for part b.

What can you say about the **effect** on the F ratio of increasing the sample size?

d) What **conclusion** can you draw based on the F ratios found in part c?

F_{CV} (_____ , _____) = ___________

What are the **limitations** on these conclusions (in terms of causation)?

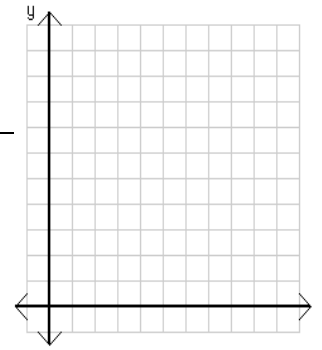
14	B	7. Two-way ANOVA in R with by-hand contrasts	Code: R notebook

A college is conduction a study of its students' expectations of employment upon graduation. Students are sampled by class and major area of study and are given a scores from 0 to 35 according to their responses to a questionnaire concerning their job preparedness, goal orientation, and so forth. (see book for data)

a) Perform a two-way ANOVA and create a summary table.

	SS	df	MS	F	p
ERROR (residual)					
TOTAL					

b) Draw a graph of the cell means.



Does the interaction **obscure** the interpretation of the main effects?

c) Use Tukey's HSD to determine **which pairs** of class years differ significantly.

For just **the freshmen and seniors**, calculate the three possible interaction contrasts.

Humanities vs. Sciences

Estimate$_{contrast}$ =

SE$_{contrast}$ =

t$_{contrast}$ =

p$_{unadjusted}$ =

F$_{contrast}$ =

Sig via Scheffe? ☐yes ☐no

Humanities vs. Business

Estimate$_{contrast}$ =

SE$_{contrast}$ =

t$_{contrast}$ =

p$_{unadjed}$ =

F$_{contrast}$ =

Sig via Scheffe? ☐yes ☐no

Sciences vs. Business

Estimate$_{contrast}$ =

SE$_{contrast}$ =

t$_{contrast}$ =

p$_{unadjusted}$ =

F$_{contrast}$ =

Sig via Scheffe? ☐yes ☐no

Which, if any, would be **significant** according to Scheffe's test? (formula 14.1, table A.11)

Formula 13.16 (2-way)
$F_s = df_{int}\, F_{cv}(df_{int}, df_w)$

F$_{Scheffe}$ =

14	B	8. 2-way vs. 1-way ANOVA	Code: R notebook

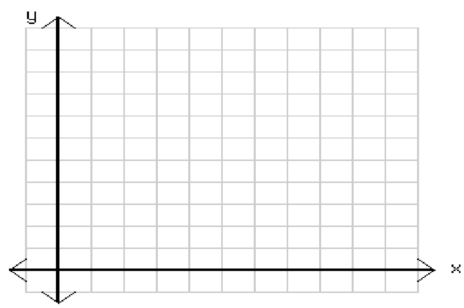
The data from exercise 12B8 for a four-group experiment on attitudes and memory are shown in the book (we didn't do it). Considering the relationships among the four experimental conditions, it should be obvious that it makes sense to analyze these data with a two-way ANOVA.

a) Perform a two-way ANOVA and create a summary table.

	SS	df	MS	F	p
ERROR (residual)					
TOTAL					

b) Compare your summary table to the one ~~you produced for exercise 12B8~~ you get from a four group one-way ANOVA

	SS	df	MS	F	p
Between Groups					
ERROR (residual)					
TOTAL					



c) What **conclusions** can you draw from the two-way ANOVA?
(It will help to plot the means on the grid above)

14	C	1. Two-way ANOVA with followup	Code: R notebook

a) Using college major and gender as your independent variables, perform a two-way ANOVA on mathquiz. Request **descriptive** statistics and an **HOV** test.

Calculate the ordinary eta squared for each factor. (formula 12.10, page 495)

Formula 12.10

$$ordinary\ \eta^2 = \frac{SS_{effect}}{SS_{total}}$$

Major: ord. η^2=

Report your results in APA style.

Gender: ord. η^2=

b) Given the ANOVA results, perform an appropriate follow-up test. ← use Tukey's HSD in R

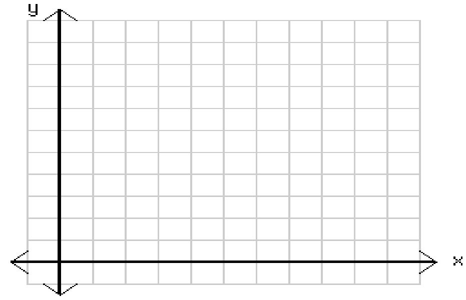
Explain your results in terms of the descriptive statistics.

	Psychology (n = _______)	Premed (n = _______)	Biology (n = _______)	Sociology (n = _______)	Economics (n = _______)
Math Quiz					

14	C	4. Two-way ANOVA with followup	Code: R notebook

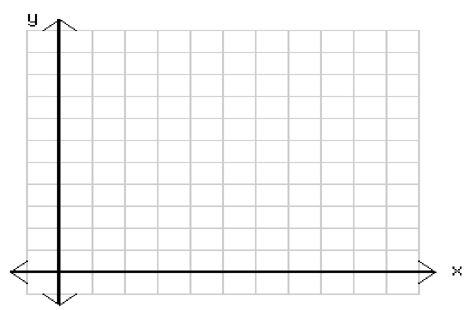
a) Using the phobia grouping variable you created for Exercise 5 in Chapter 12 and gender as your IVs, perform a two-way ANOVA on mathquiz. Request the appropriate post hoc test and a plot of the cell means, and

Report the results in **APA style**.



b) Repeat part a (except post hoc) after deleting the moderate phobia group from the analysis .

What type of **interaction** do you see in the plot?

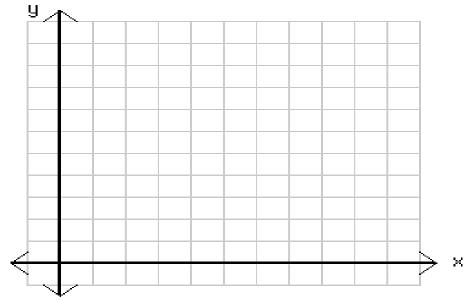


Test the simple **main effect** of phobia for each gender.

Do you need to follow up any of the simple main effects with pairwise comparisons? Explain.

14	C	5. Two-way ANOVA with followup	Code: R notebook

a) Using the phobia grouping variable you created for Exercise 5 in Chapter 12 (do not drop any phobia groups for this exercise) and coffee (regular coffee drinker or not) as your IVs, perform a two-way ANOVA on the post-quiz heart rate. Request an HOV test, observed power, and a plot of the cell means.



Does the **HOV** test give you cause for concern?

Explain the **ANOVA** results in terms of the plot you created.

b) Request an appropriate post hoc test to follow-up your ANOVA results, and report the results.

Calculate the ordinary eta squared for each main effect

Formula 12.10

$$ordinary\ \eta^2 = \frac{SS_{effect}}{SS_{total}}$$

Coffee: ord. η^2=

Phobia: ord. η^2=

How **large** is each effect?