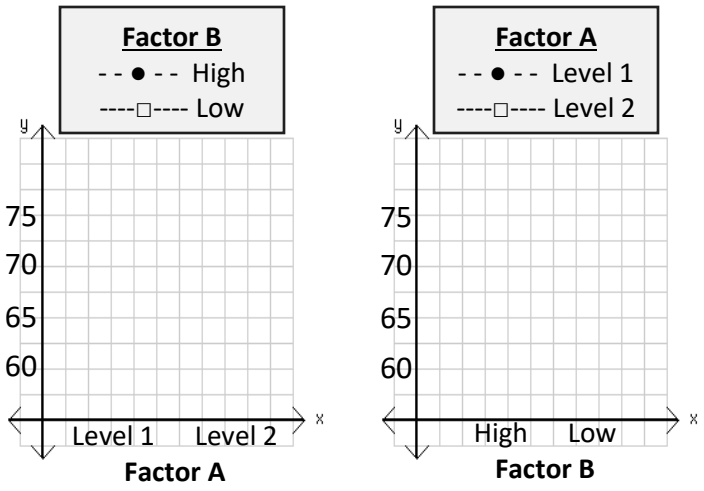
14 A | 2. Marginal Means & two-way effects from cell means

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



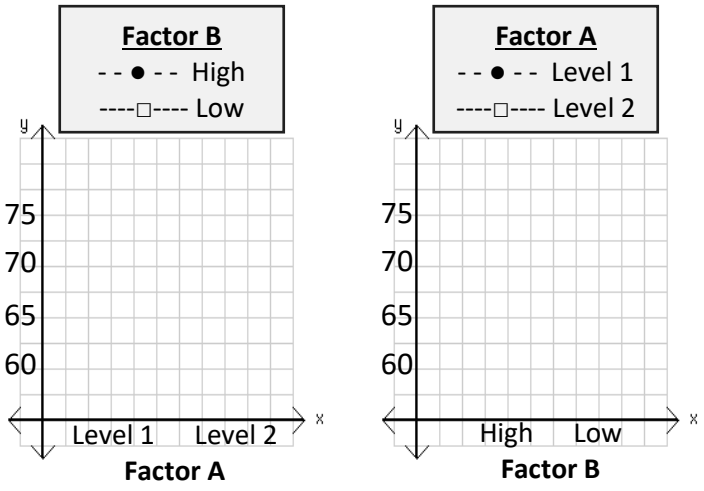
b) Which effects might be **significant**, and which **cannot** be significant?

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 B \ Factor A	Level 1	Level 2	
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$_{with}$ =

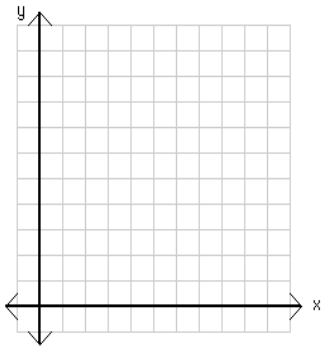
b) Calculate the **three F ratios**. (Hint: check to see if there is an interaction. If there is none, the calculation is simplified)

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

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

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

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

Factivity **(** __ **,** _____**) =** _____

Fdiet **(** __ **,** _____**) =** _____

Finteract **(** __ **,** _____**) =** _____

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?

FCV **(** _____ **,** _____**) =** _____

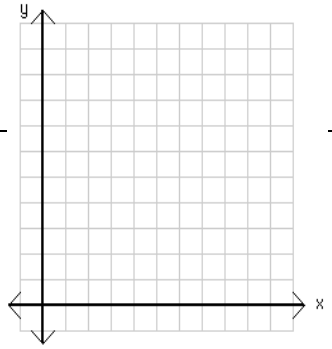
What are the **limitations** on these conclusions (in terms of causation)?

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

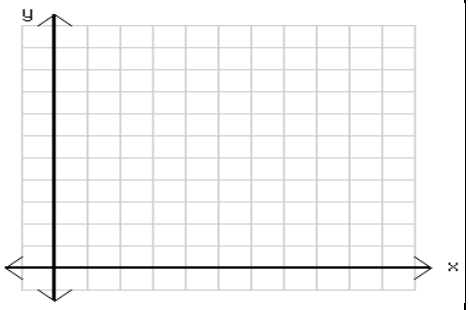
The data from exercise 12B8 for a four-group experiment on attitudes and memory are shown in the book (we didn't do it). Considering the relationships among the four experimental conditions, it should be obvious that it makes sense to analyze these data with a two-way ANOVA.

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

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

Report your results in APA style.

Major: ord. η^2=

Gender: ord. η^2=

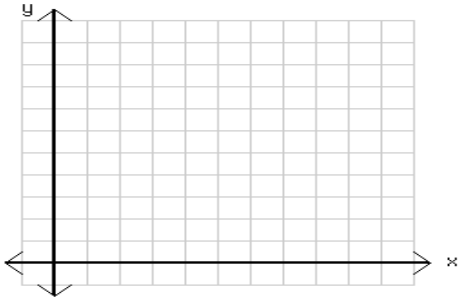
b) Given the ANOVA results, perform an appropriate follow-up test. ← use Tukey's HSD in R

Explain your results in terms of the descriptive statistics.

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

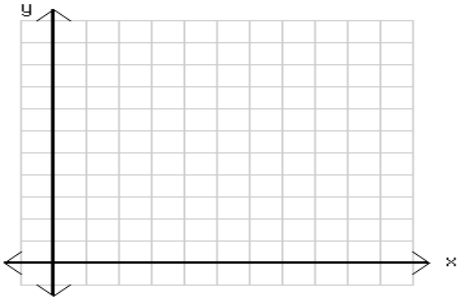
14	C	4. Two-way ANOVA with followup	Code: R notebook

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 .



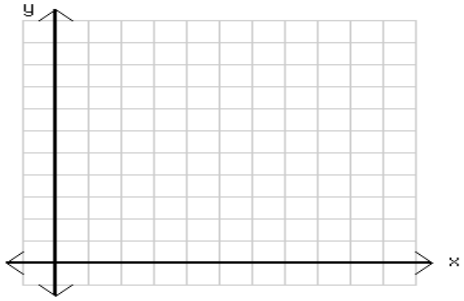
What type of **interaction** do you see in the plot?

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?