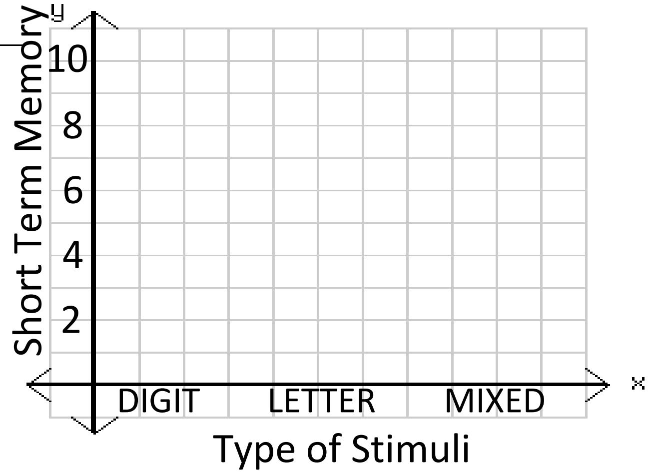
15 A 2. Visual examination for interaction

The data in the following table are from an experiment on short-term memory involving three types of stimuli: digits, letters, and a mixture of digits and letters.

Draw a **graph** of these data (1 line per subject) and…

Subject	Digit	Letter	Mixed
1	6	5	6
2	8	7	5
3	7	7	4
4	8	5	8
5	6	4	7
6	7	6	5



Describe the **degree of the interaction** between the various pairs of levels.

15 A 4. RM ANOVA – calculations by hand

In exercise 12A #7, eight subjects were tested for problem-solving performance in each of four drug conditions, yielding the following means and standard deviations:

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

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

If the **SAME** eight subjects were tested in all four conditions, and if the **SS_{sub} = 190.08**, how large would the **F ratio** for the RM ANOVA be?

Formula 12.7
$$MS_{RM} = n\frac{\sum(\bar{x}_i - \bar{x}_G)^2}{k-1}$$

Formula 15.2B
$$df_{RM} = c - 1$$

Formula 15.3A
$$SS_{RM} = MS_{RM} \cdot df_{RM}$$

Formula 12.5B
$$MS_W = \frac{\sum s_i^2}{k}$$

Formula 12.4B
$$df_W = n_T - k$$

Formula 12.9
$$SS_W = MS_W \cdot df_W$$

Formula 15.1
$$SS_{inter} = SS_{WG} - SS_{sub}$$

Formula 15.2C
$$df_{inter} = (n-1)(c-1)$$

Formula 15.3B
$$MS_{inter} = \frac{SS_{inter}}{df_{inter}}$$

Formula 15.4
$$F_{RM} = \frac{MS_{RM}}{MS_{inter}}$$

F_{RM} (______ , ______) = ____________

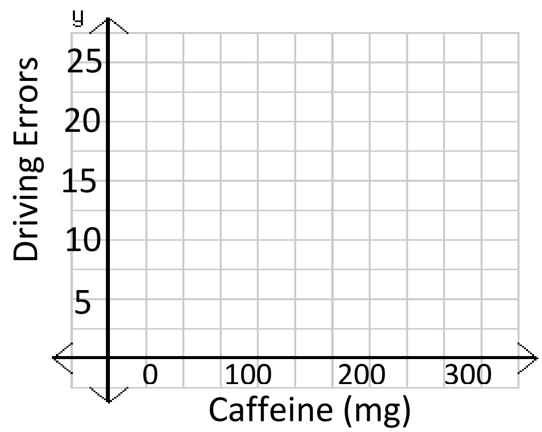
15 A 5. 1-way RM ANOVA – calculations by hand

In exercise 13B #16, independent groups of subjects performed a video game after being given one of four possible doses of caffeine (including zero). In this exercise, we will imagine that the subjects had been matched into blocks of four before being randomly assigned to one dosage level or another.

Block #	0 mg	100 mg	200 mg	300 mg	mean
1	25	16	6	8	13.75
2	19	15	14	18	16.5
3	22	19	9	9	14.75
4	15	11	5	10	10.25
5	16	14	9	12	12.75
6	20	23	11	13	16.75
mean	19.5	16.3333	9	11.6667	14.125

a) **Graph** these data, with caffeine amount on the x-axis and the blocks represented by separate lines. The outcome is the number of driving errors each subject makes in the video simulation game.

Describe the **general trend** of the data with respect to caffeine dosage.



Does the amount of the subject-by-dosage-level interaction look relatively **large or small**?

b) Calculate the **F ratio** for a one-way RM ANOVA on these data.

Formula 14.3: $SS = n_T \times \sigma^2(M's)$

$$\sigma^2(all\ 24\ values) = 28.03, \quad \sigma^2(4\ column\ means) = 16.52, \quad \sigma^2(6\ subject\ means) = 4.99$$

Formula 15.1
$SS_{inter} = SS_{Tot} - SS_{RM} - SS_{sub}$

Formula 15.2C
$df_{inter} = (n-1)(c-1)$

Formula 15.3B
$MS_{inter} = \frac{SS_{inter}}{df_{inter}}$

Formula 15.2B
$df_{RM} = c - 1$

Formula 15.3A
$MS_{RM} = \frac{SS_{RM}}{df_{RM}}$

Formula 15.4
$F_{RM} = \frac{MS_{RM}}{MS_{inter}}$

F_{RM} (_____ , _____) = _________ , p = _________

Can the null hypothesis be rejected at the **.05 level**? F_{crit}(____, ____) = _________ ☐ yes ☐ no

At the **.01 level**? F_{crit}(____, ____) = _________ ☐ yes ☐ no

15	B	3. 1-way RM ANOVA	Code: R notebook

A psycophysiologist wishes to explore the effects of public speaking on the systolic blood pressure of young adults. **Three conditions** are tested. The subject must vividly imagine delivering a speech to **one person**, to a s**mall class** of 20 persons, or to a **large audience** consisting of hundreds of fellow students. Each subject has his or her **systolic blood pressure measured (mmHg)** under all three conditions. Two subjects are randomly assigned to each of the six possible treatment orders. (The data are in the textbook.)

a) Perform an RM ANOVA on the blood pressure data and write the **results in words**, as they would appear in a journal article.

(Note: you will need to over-ride the defualt and make No correction for spericity violations)

````
```{r}
# RM ANOVA: type 3 SS, no correction for lack of Spericity
fit_audience <- audience_long %>%
  afex::aov_4(blood_pressure ~ 1 + (audience|id),
              data = .,
              anova_table = list(correction = "none",
                                 es = c("ges", "pes")))

fit_audience
```
````

F_{RM} (____ , ____) = __________ , p = ______

Does the size of the audience have a **significant effect** on blood pressure at the .05 level? ☐ yes ☐ no

b) What might you do to minimize the possibility of **carryover effect**?

c) Calculate the $\boldsymbol{\eta^2_{RM}}$ from the F ratio you calculated in part a.

(note the two values from R, but also calculate by hand)

Formula 15.5

$$\eta^2_{RM} = \frac{SS_{RM}}{SS_{RM} + SS_{S*RM}}$$

☐ ges = general eta-squared = __________

☐ pes = partial eta-squared = __________

$\boldsymbol{\eta^2_{RM}}$ =

Does this look like a **large** effect? ☐ yes ☐ no

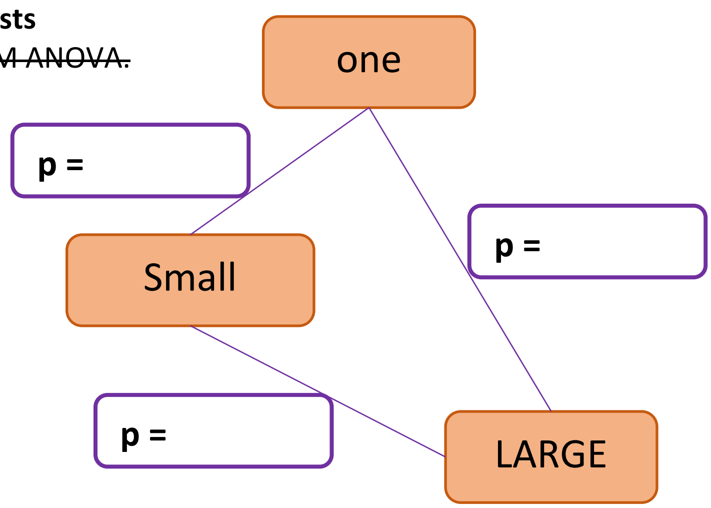
How could this effect size be **misleading** in planning future experiments?

☐ yes
☐ no

d) Test all the pairs of means with **protected t tests** (Fisher's LSD) ~~using the error term from the RM ANOVA.~~

````
```{r}
# RM ANOVA: post hoc all pairwise tests
fit_audience %>%
  emmeans::emmeans(~ audience) %>%
  pairs(adjust = "none")
```
````

Which pairs **differ** significantly at the **.05 level**?



15	B	4. 1-way RM ANOVA	Code: R notebook

A statistics professor wants to know if it really matters which textbook she uses to teach her course. She selects **four textbooks** that differ in approach and then matches her **36 students into blocks of four** based on their similarity in math background and aptitude. Each student in each block is randomly assigned to a different text. At some point in the course, the professor gives a surprise 20-question **quiz**. The number of questions each student answers correctly appear in the table in the textbook.

a) Perform an RM ANOVA on the data, and present the results of your ANOVA in a **summary table**.

```{r}
# RM ANOVA: display all Sums-of-Squares components
fit_textbook <- textbook_long %>%
  afex::aov_4(quiz ~ 1 + (book|block),
              data = .)

fit_textbook$aov
```

Source	SS	df	MS	F	p
RM = ____________________					
Residual: (RM x Sub)					

Does it **make a difference** which textbook the professor uses?

☐ yes
☐ no

b) Considering your answer to part a, what **type of error** could you be making?

☐ type I
☐ type II

c) If ~~you were to assume a maximum violation of~~ the **sphericity assumption** was corrected for using the **Greenhouse-Geisser (afex default)** epsilon adjustment to the degrees of freedom.
Note: the sum-of-squares remain the same, the degrees of freedom do change…

```{r}
# RM ANOVA: GG correction for lack of Spericity
fit_textbook
```

Source	SS	df	MS	F	p
RM = ____________________					
Residual: (RM x Sub)					

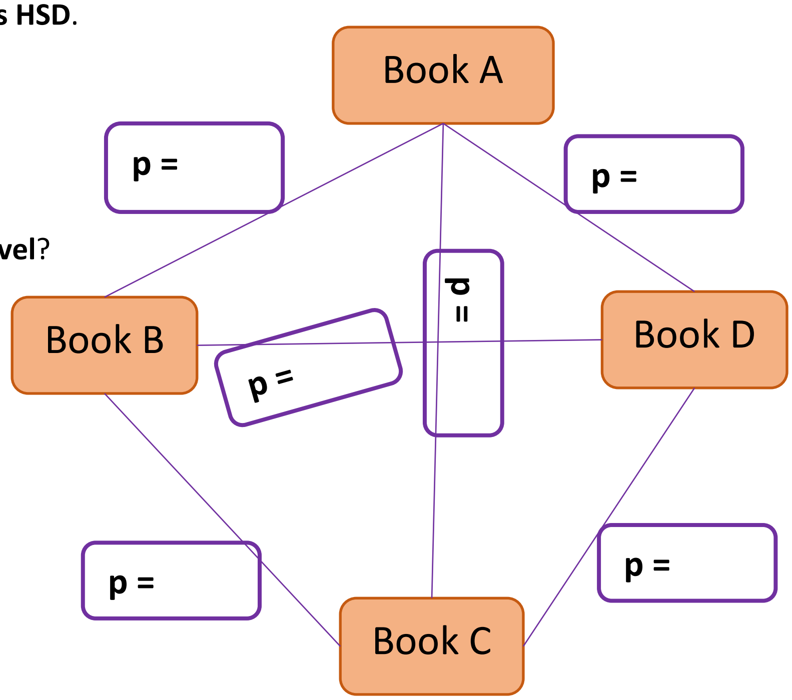
Would your F ratio from part (a) be significant at the **.01 level?**

☐ yes
☐ no

d) Test **all the pairs of means with Tukey's HSD**.

````
```{r}
# RM ANOVA: post hoc all pairwise tests
#           with Tukey's HSD correction
fit_textbook %>%
  emmeans::emmeans(~ book) %>%
  pairs(adjust = "tukey")
```
````

Which pairs differ significantly at the **.05 level**?



15 B	5. 1-way independent groups ANOVA vs. RM ANOVA	Code: R notebook

a) Continue with #4...Perform an 1-way Independent groups ANOVA on the data.

````
```{r}
# 1-way ANOVA: 1 between-subject factor
fit_book1way <- textbook_long %>%
  afex::aov_4(quiz ~ book + (1|id),
              data = .)

fit_book1way$aov
```
````

Source	SS	df	MS	F	p
Between-Group = ___________					
Within-Group = Residual					

b) Does the choice of **text make a significant difference** when the groups of subjects are considered to be independent (i.e., the matching is ignored)?

☐ yes

☐ no

c) **Compare** your solution to this exercise with your solution to exercise #4.
Which part of the F ratio remains **unchanged**?

What can you say about the **advantages of matching** in this case?

15 B 6. 1-way RM ANOVA **Code: R notebook**

A neuropsychologist is exploring short-term memory deficits in people who have suffered damage to the left cerebral hemisphere. He suspects that memory for some types of material will be more affected than memory for other types. To test this hypothesis he presented six brain-damaged subjects with stimuli consisting of strings of digits, strings of letters, and strings of digits and letters mixed. The longest string that each subject in each stimulus condition could repeat correctly is presented in a table in the textbook. (One subject was run in each of the six possible orders.)

a) Perform an RM ANOVA (assume sphericity IS NOT violated)

F_{RM} (_____ , _____) = ________ , p = ________

Is your calculated F value significant at the **.05 level**?

☐ yes ☐ no

b) Would your conclusion in part a **change** if you could **not assume that sphericity** exists in the population underlying this experiment?

F_{RM} (_____ , _____) = ________ , p = ________

☐ yes ☐ no

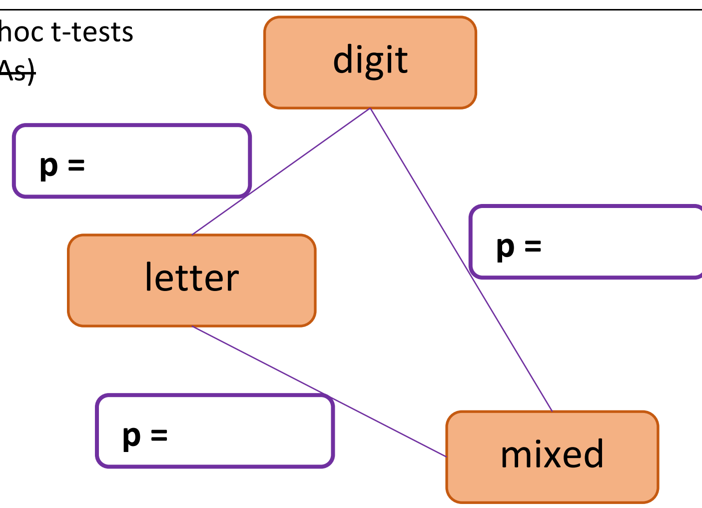
Explain.

c) Based on the **graph you drew** of these data for exercise 15A #2, would you say that the RM ANOVA is appropriate for these data?

☐ yes ☐ no

Explain.

d) Test **all the possible pairs** of means with post-hoc t-tests ~~separate matched t tests (or two-group ANOVAs)~~ **Fisher's LSD** at the **.01 level.**



15	C	1. RM anxiety over time – separately by gender	Code: R notebook

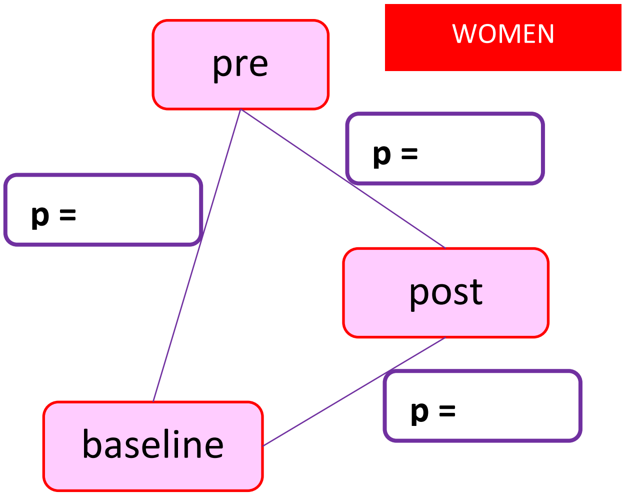
a) Use **SPLIT FILE** to perform **separate** RM ANOVAs for **men and women** to test for a significant change in **anxiety level over time** (baseline, pre-quiz, and post-quiz). Request **pairwise tests** and fill out the ~~table~~ FIGURES below with the appropriate **p-values** **IF the omnibus F-test was significant**.

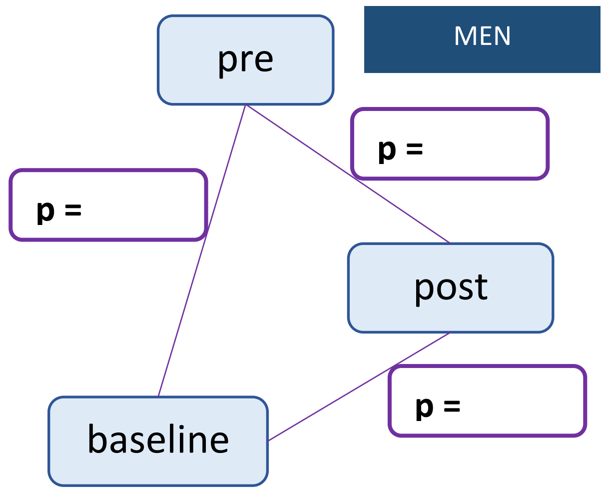
F_{RM} (_____ , _____) = ________

p = __________

F_{RM} (_____ , _____) = ________

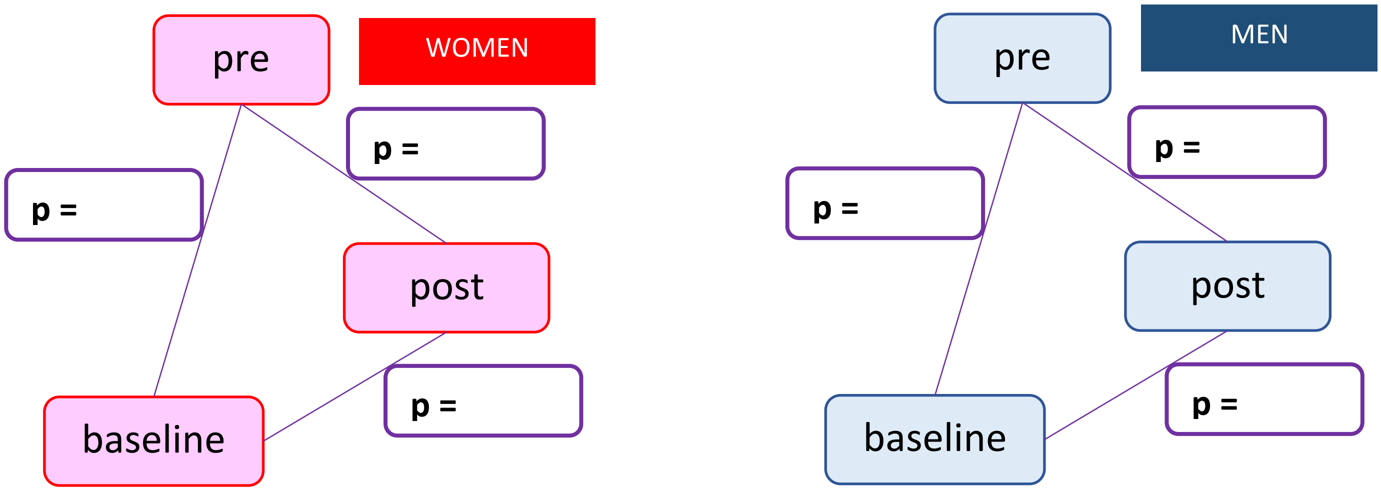
p = __________





Write up your results in **APA style**.

b) Perform **matched t tests** for each pair of RM levels, STILL BY GENDER. Fill out the table below with the appropriate **p-values <u>IF the omnibus F-test was significant.</u>**



Compare these **p values** to those produced in the ***Pairwise Comparisons*** results box of the RM ANOVA output produced for part (a) above.

15	C	3. RM stats quiz – experimental quiz vs. regular stats quiz

Perform an RM ANOVA to determine whether there is a significant difference in mean scores between the experimental stats quiz and the regular stats quiz. **Code: R notebook**

Compare this F ratio with the **matched t value** you obtained from exercise #3 in chapter 11 C.

RM ANOVA: F(______ , ______) = ____________ , p = ___________

Matched pair: t(_____) = ____________ , p = ___________