Exam 3
Psych 2111, Fall 16

Vocabulary

1. Factor: nominal-scale (i.e. categorical) variable used as a predictor in an ANOVA

2. Individual differences: differences among individuals that affect each person's scores in all conditions of a repeated-measures design

3. Explained variability: variability in the outcome variable in a regression or ANOVA that can be accounted for by differences in the values of the predictors or factors

4. Regression coefficient: number indicating how much the predicted outcome changes with changes in a given predictor

5. Interaction: pattern in which the effect of one factor on the outcome differs depending on the value of another factor

Conceptual questions

1. You run an ANOVA and get an F value of 2.17. This leads you to retain the null hypothesis. Then you find an error in your calculation and determine the correct F value is 2.75 (but the degrees of freedom and α don't change). What is your new conclusion—reject the null, retain it, or not enough information to tell?

Not enough information—we know the critical value is above 2.17, but that isn't enough to determine whether it's above or below 2.75.

2. In a test of social priming, subjects are given a word search containing either neutral terms or elderly stereotypes (*retirement*, etc.). Afterward, they're secretly timed in their walking speed as they leave the lab, either past a mirror or past a blank wall. Word type (neutral vs. stereotyped) and mirror (present vs. absent) are found to have an interaction in predicting walking speed. Write in words what this means.

The effect of word type for subjects walking past a mirror is different from the effect of word type for subjects walking past a blank wall. For example, mirror subjects might be slower if they saw stereotyped words than if they neutral words, whereas wall subjects might be unaffected by word type.

3. Two variables have a correlation of 0, but they're not independent. When can this happen? You can answer with a sentence or a scatterplot.

This can happen when the variables have a nonlinear relationship.

4. A one-way between-subjects ANOVA is run for an experiment with two groups. What other hypothesis test could have been used to answer the same question?   Independent-samples t-test

A repeated-measures ANOVA is run for an experiment with two measurements per subject. What other hypothesis test could have been used to answer the same question?   Paired-samples t-test

5. We measure a group of subjects' heights, and the results are recorded in both inches and centimeters. What can you say about the correlation between these two variables? Be as specific as possible.

The two variables have a perfect linear relationship, so their correlation is exactly 1.

Math questions

1. In a study testing the theory that cognitive control is a limited resource, subjects are given a set of math problems and then offered to take a handful of jellybeans as they leave the lab. We measure how long it takes each subject to complete the math problems and how many jellybeans they take, and convert both variables to z-scores. Calculate the correlation between these two variables.

Subject	z_{math}	z_{candy}	$z_{math} \cdot z_{candy}$	$r \cdot z_{math}$	$z_{candy} - \hat{z}_{candy}$	$(z_{candy} - \hat{z}_{candy})^2$
1	1.11	0.72	0.7992	0.9701	-0.2501	0.0626
2	-0.62	-0.40	0.2480	-0.5419	0.1419	0.0201
3	-0.02	0.77	-0.0154	-0.0175	0.7875	0.6201
4	0.84	0.49	0.4116	0.7342	-0.2442	0.0596
5	-1.30	-1.58	2.0540	-1.1362	-0.4438	0.1970

$$r = \frac{\sum z_{math} \cdot z_{candy}}{n-1} = \frac{3.4974}{4} \simeq \underline{0.874}$$

2. Using the data from Question 1, test whether amount of candy is predicted by math time. First, use the correlation you calculated together with each person's math time to get a prediction for their candy consumption ($\hat{z}_{candy}$). Then use those predictions and the actual values of z_{candy} to do an F test. The degrees of freedom are $df_{regression} = 1$ and $df_{residual} = 3$, and the critical value (for $\alpha = 5\%$) is $F_{crit} = 10.13$. (It's fine to do regression using z-scores instead of raw scores. In fact it's a bit easier: We know the variance of z_{candy} equals 1, and therefore $SS_{total} = var(z_{candy}) \cdot (n-1) = 4$.)

The prediction is $\hat{z}_{candy} = r \cdot z_{math}$, which I put in the table above.

$$SS_{res} = \sum (z_{candy} - \hat{z}_{candy})^2 = 0.9594$$
$$SS_{reg} = SS_{total} - SS_{res} = 4 - 0.9594 = 3.0406$$
$$MS_{res} = \frac{SS_{res}}{df_{res}} = \frac{0.9594}{3} \simeq 0.3198$$
$$MS_{reg} = \frac{SS_{reg}}{df_{reg}} = \frac{3.0406}{1} = 3.0406$$
$$F = \frac{MS_{reg}}{MS_{res}} = \frac{3.0406}{0.3198} \simeq 9.5078$$

$F < F_{crit}$, so we retain the null hypothesis that quantity of candy is not predicted by time on the math test.

3. The following table shows the steps of a factorial ANOVA with two factors, A and B. Fill in the missing entries. Recall that the total df is the sum of the other four dfs.

Effect	SS	df	MS	F
A	32.4	9 (A)	3.6	2.57 (H)
B	18.8	4	4.7 (B)	3.36 (I)
A:B	75.6	36	2.1 (C)	1.5
Residual	109.2 (F)	78 (E)	1.4 (D)	N/A
Total	236 (G)	127		

The missing entries can be found in the order indicated (A-I).

4. Subjects are asked to give a speech in each of three conditions: alone in front of a mirror, in a group of strangers, and in a group of friends. The number of speech errors (stutters, etc.) is recorded for each subject in each condition. Test whether the mean number of errors differs across conditions. The total sum of squares equals 114, the degrees of freedom are $df_{\text{treatment}} = 2$, $df_{\text{subject}} = 4$, $df_{\text{residual}} = 8$, and the critical value is $F_{\text{crit}} = 4.46$.

		Condition		
Subject	Mirror	Strangers	Friends	Mean
1	5	10	6	7
2	9	13	11	11
3	6	9	9	8
4	9	14	13	12
5	6	9	6	7
Mean	7	11	9	9

$$SS_{\text{subject}} = \sum k \cdot (M_s - \bar{M})^2 = 3 \cdot 2^2 + 3 \cdot 2^2 + 3 \cdot 1^2 + 3 \cdot 3^2 + 3 \cdot 2^2 = 66$$

$$SS_{\text{treatment}} = \sum n \cdot (M_i - \bar{M})^2 = 5 \cdot 2^2 + 5 \cdot 2^2 + 5 \cdot 0^2 = 40$$

$$SS_{\text{residual}} = SS_{\text{total}} - SS_{\text{subject}} - SS_{\text{treatment}} = 114 - 66 - 40 = 8$$

$$MS_{\text{treatment}} = \frac{SS_{\text{treatment}}}{df_{\text{treatment}}} = \frac{40}{2} = 20$$

$$MS_{\text{residual}} = \frac{SS_{\text{residual}}}{df_{\text{residual}}} = \frac{8}{8} = 1$$

$$F = \frac{MS_{\text{treatment}}}{MS_{\text{residual}}} = \frac{20}{1} = 20$$

$F > F_{\text{crit}}$, so we reject the null hypothesis and conclude that the manipulation of social context affected subjects' mean number of speech errors.

5. Now treat the data in Question 4 as though they were from a between-subjects design, that is, with five different subjects in each condition. Test whether the mean number of errors differs across groups. The degrees of freedom are now $df_{\text{treatment}} = 2$ and $df_{\text{residual}} = 12$, and the critical value is $F_{\text{crit}} = 3.89$.

The new SS_{residual} equals the old SS_{residual} plus SS_{subject}: $66 + 8 = 74$

$$MS_{\text{residual}} = \frac{SS_{\text{residual}}}{df_{\text{residual}}} = \frac{74}{12} \simeq 6.17$$

$$F = \frac{MS_{\text{reg}}}{MS_{\text{res}}} = \frac{20}{6.17} \simeq 3.24$$

$F < F_{\text{crit}}$, so we retain the null hypothesis that the manipulation of social context did not affect subjects' mean number of speech errors. The change to a between-subjects design added enough uncertainty to our condition means that the conclusion changed.

R questions

1. Describe what will be in the output of the following command. Be as specific as possible.
```
> lm(reaction.time ~ stimulus.size + stimulus.intensity)
```

This will give an intercept and regression coefficients for stimulus size and stimulus intensity, for a regression equation to predict reaction time.

2. Make up numbers for the output in Question 1, and then figure out the predicted reaction time for a stimulus of size 3 and intensity 2.

$b_0 = 500$, $b_{\text{stimulus.size}} = -25$, $b_{\text{stimulus.intensity}} = -50$

$\widehat{reaction.time} = 500 - 25 \cdot 3 - 50 \cdot 2 = \underline{325}$

3. Subjects in a memory experiment testing context specificity are given words to `study` either while scuba diving or while on the beach, and they are later given a `test` either at the bottom of a swimming pool or while sitting at a table. Write three conclusions based on the following ANOVA output.

```
Analysis of Variance Table

Response: memory
            Df Sum Sq Mean Sq F value    Pr(>F)
study        1    0.8     0.8  0.4706 0.502537
test         1   24.2    24.2 14.2353 0.001665
study:test   1    3.8     3.8  2.2359 0.154352
Residuals   16   27.2     1.7
```

a) The p-value for `study` indicates that where people study has no main effect on test scores

b) The p-value for `test` indicates that where people are tested has a main effect on test scores

c) The p-value for the interaction indicates that the effect of where people are tested is the same regardless of where they study

4. Based on the information in the previous question, what is the output of the following command?

`> pf(2.2359,1,16,lower.tail=FALSE)`

This command calculates a p-value for $F = 2.2359$, on 1 and 16 degrees of freedom. The table shows that value is $\underline{0.154352}$.

5. Write a conclusion based on each of the underlined p-values in the output below. Your conclusions should be about the variables, not just something like "retain/reject the null hypothesis."

`> summary(lm(energy.output ~ panel.area + sunlight))`

```
Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)     0.16077    0.25110   0.640   0.5251
panel.area     -0.08348    0.06029  -1.385   0.1727
sunlight       -0.13345    0.05659  -2.358   0.0226

Residual standard error: 1.721 on 47 degrees of freedom
Multiple R-squared: 0.1375,    Adjusted R-squared: 0.1008
F-statistic: 3.748 on 2 and 47 DF,  p-value: 0.03089
```

`0.1727`: Panel area does not affect energy output (given the amount of sunlight)

`0.0226`: Amount of sunlight has a negative effect on energy output (given the panel area)

`0.03089`: Panel area and amount of sunlight taken together are predictive of energy output