Homework #6: Repeated measures t-tests.
Due: In lab, March 11-14

DIRECTIONS: For this homework, please turn in hard copies in class on Wed, Feb 13. This homework counts double. Write answers out in a separate Microsoft Word document (note that some questions may not require an answer – so you can skip these or just say "completed" – but we'll try to put what the actual question to be answered, or what you need to do to get credit, by placing that in **bold** in the question). We encourage you to work in groups for R-related material, but make sure to do the work yourself too and *always* come up with independent answers. Homeworks that have identical answers will receive F's.

Part 1 - Repeated Measures T-test

Q1) One method for assessing the effectiveness of a drug is to note its concentration in urine samples at certain periods of time after giving the drug. Suppose we want to compare the concentrations of two types of aspirin (types A and B) in urine specimens taken from the same person, 1 hour after he or she has taken the drug. Hence, a specific dosage of either type A or type B aspirin is given at one time and the 1-hour urine concentration is measured. One week later, after the first aspirin has presumably been cleared from the system, the same dosage of the other aspirin is given to the same person and the 1-hour urine concentration is noted. Since the order of giving the drugs may affect the results, a table of random numbers is used to decide which of the two types of aspirin to give first. This study is performed on 10 people; the results are available in the dataset **aspirin**, available from loading the datasets:
load(url("http://www.matthewckeller.com/Stats3101/Stat3101.Datasets-2013.RData"))

Note: if the drug is in the urine, it is no longer in the body providing pain relief. Therefore, lower scores are associated with more pain relief. Finally, we can assume that the scores (and score differences) come from a population of scores that are roughly normally distributed.

A) Let us say that the two samples are independent (the people in the group "aspA" are different people and in no way linked to the people in "aspB") and that people in both samples were randomly assigned to either take aspA or aspB. **Use an independent samples t-test to answer whether aspA is more or less effective than aspB. What is your alternative and null hypotheses? Your t-value and p-value? What do you conclude?** Note: You can look up the code (or how to do this from the menu) for conducting a two-sample t-test from the last homework (make sure to assume equal variances between the two populations, which is all we've learned in this class). On the in-lab final, I won't be supplying the code, so this is practice for doing that.

B) **Write a four sentence summary of your findings. Make sure to include an estimate of the "effect size" (i.e., Cohen's d) of the effect you found, and include a side-by-side boxplot** of aspirin concentration in urine below your 4-sentence summary.

C) **The results of your t-test should not have been significant, but if they were significant, could we make causal inference based on this study?** Hint: Causal inference means that we can infer that the independent variable CAUSED a change in the dependent variable - not just

that a relationship between two variables exist. For example, there is a relationship between ice cream sales and swimming pool deaths - on days when ice cream sales spike, swimming pool deaths spike. But in this case, it is very unlikely that ice cream CAUSES swimming pool deaths (both tend to occur on hot days). In science, we can only infer causation when we have kept everything constant between two conditions except for the independent variable, which we manipulate. With respect to this question, this is an experiment because everything is constant between aspA and aspB but we've manipulated whether people have aspA or aspB.

D) Now let us say that the two samples are NOT independent. Rather person 1 took aspA at one time and a week later took aspB, and that person's scores are recorded on the first row under "aspA" and "aspB". **Perform a repeated measures t-test to answer whether aspA is more or less effective than aspB. What is your alternative and null hypotheses? Your t-value and p-value? What do you conclude?** Note: you can do this through the Menu system (Statistics -> Means -> Paired t-test) or using the following code:

```
t.test(aspirin$aspA,aspirin$aspB, paired=TRUE)
```

E) **Write a four sentence summary of your findings. Make sure to include an estimate of the "effect size" (i.e., Cohen's d) of the effect you found, and include a boxplot of difference scores of aspirin concentration in urine below your 4-sentence summary.** To get a Cohen's d in this situation, you should subtract aspA from aspB, and then get the Cohen's d value exactly like you would (and did previously) for a one-sample t-test. The denominator here is the standard deviation of the difference scores. To get a difference score in R:

```
diff.score <- aspirin$aspA-aspirin$aspB
sd(diff.score)
mean(diff.score)
boxplot(diff.score)
```

F) **Explain in words your grandmother could understand what the "p-value" of your test above means.**

G) **Explain intuitively why your conclusion in (D) is different than your conclusion in (A).**

Q2) Below are the ten scores for each of the 10 people. **Conduct your repeated measures t-test by hand on these 10 pairs of scores and report your t-value and p-value** (you'll need to either look up the relevant p-value from the back of the book – which is good practice for you – or look it up using the pt() function in R).

person	aspA	aspB
1	15	13
2	26	20
3	13	10
4	28	21
5	17	17
6	20	22
7	7	5
8	36	30

9	12	7
10	18	11

Make sure to show your work. **You'll need to show all steps – (a) finding the mean difference; (b) finding the standard deviation of the mean differences in the sample; (c) finding the standard error of the mean difference; (d) finding the t-value; (e) finding the p-value.** Do you get the same t- and p-values as your answer in (D)? You should!

Q3) You have a hypothesis that having a long-term mate decreases the desire to go out and party and increases the desire to study. In particular, you predict that college students with boyfriends or girlfriends will study more than people without girlfriends or boyfriends. You ask 63 college students without girlfriends or boyfriends and 45 college students with them how much time they spend studying during a typical week. The results of this t-test are shown below:

```
> t.test(study.hours~mate,var.equal=TRUE)

        Two Sample t-test

data:  lab_survey$study_hours_weekly by lab_survey$girl_boyfriend

t = -2.1909, df = 106, p-value = 0.03065

alternative hypothesis: true difference in means is not equal to 0

sample estimates:

mean in group No_mate          mean in group Yes_mate

      13.71094                       17.31818
```

A) **What is the 95% confidence interval for the mean difference between the two groups? To answer this, you'll first have to figure out (by hand) (a) what the standard error of the mean is (b) what the critical value of a t-distribution is given 106 degrees of freedom, and finally (c) use those two pieces of information to figure out the confidence interval.** You have all the information here you need to answer this question (except for the critical t-value that corresponds to an alpha level of .05– which you have to look up in the table in your book), and similar kinds of questions may be on the test, so make sure you can do this. The function qt() in R is an alternative way to look up a critical t-value. The first argument of qt() is the percent of scores below the t-value you want (i.e., .025 for an alpha of .05) and the second argument is the df. I.e.:

```
qt(.025,106)  #gives the lower bound t-value; the upper bound is -1* this number
```

B) **What is the 99% confidence interval for the same test? Why is your answer in (B) different than your answer in (A)?** Show your work by hand.

C) **If you observed the exact same mean difference as above, but instead you had asked 10,000 people, what would your confidence interval of the mean difference between the two groups be? Explain intuitively why your confidence interval in (A) is different than your confidence interval in (C).**