MID-TERM BIOL 300: October 2014

1. (*10 points*) A recent episode of the Tonight Show had Jimmy Fallon playing Russian egg roulette. There were a dozen (12) eggs, and 4 of them were raw and 8 were boiled. The eggs were smashed on either Jimmy Fallon's or Bradley Cooper's face one by one. The first raw egg turned out to be the 6th egg.

What is the probability that in this set-up the first raw egg is the 6th egg?

$Pr[1^{st}\text{ egg is boiled}] = \frac{8}{12}$

$Pr\{2nd\text{ egg is boiled} \mid 1st\text{ egg is boiled}\} = \frac{7}{11}$

etc.

$Pr\{6th\text{ egg is raw} \mid \text{first five boiled}\} = \frac{4}{7}$

$Pr\{6th\text{ egg is first raw}\} = \frac{8}{12} \times \frac{7}{11} \times \frac{6}{10} \times \frac{5}{9} \times \frac{4}{8} \times \frac{4}{7}$

$= 0.0404$

2. (*10 points*) The area under a maple tree is carefully marked into 10cm by 10cm squares, and the number of seeds that fall into each square is counted. On average, each square received 11 seeds. If the seeds fell into each square with equal probability and independently, what is the probability that a given square received exactly 9 seeds?

Probability should follow a Poisson with mean 11 per square.

$Pr[x] = \frac{\mu^{x} e^{-\mu}}{x!}$

$Pr[9] = \frac{11^{9} e^{-11}}{9!} = 0.1085$

3. (*5 points each*) Let's compare two studies. Both are on done on the same population, and estimate the same quantity, but with separate samples. Study A has 100 individuals measured, and uses an α equal to 0.05 for all its analyses. The other study measured 1000 individuals and used an α of 0.01 for all of its analyses.

a. Assume that the null hypothesis tested by these studies is true. Which study will have the higher Type I error rate?

Study A. (The Type I error rate is α.)

b. Confidence intervals are calculated for the estimates made in each study. Which study has the higher probability of giving a confidence interval that will enclose the true mean?

Study B (the other study). Confidence intervals include the ~~[illegible]~~ true value with probability $1-\alpha$.

4. (*4 points each*) For the following data set:

23, 12, 15, 18, 21

a. What is the mean of these data?

17.8

b. What is the standard deviation?

4.44

c. What is the median?

18

5. (*16 points*) In the game of craps, one person rolls two dice until the outcome of the game is settled. The person rolling the dice wins if the first roll is a 7 or a 11, and the roller loses if the first roll is a 2, 3 or 12. Any other result on the first roll causes the game to continue to more rolls. If the dice are fair, the probability of rolling a 2, 3, or 12 is 4/36, or 0.111111. The probability of rolling a 7 or 11 is 8/36, or 0.222222. Imagine that the gaming commissions confiscates a pair of dice from a casino, and rolls those dice 1000 times. They record whether the first roll is a win, a loss, or causes the game to continue. Here's what they find: 110 losses on the first roll, 210 wins on the first roll, and 680 where the outcome was not determined on the first roll. Test whether these dice are fair.

χ^2 Goodness-of-fit test:

H_0: Proportions of wins, losses, and continuations fit those expected by fair dice.

	WIN	LOSS	CONTINUATION	Total
Observed	210	110	680	1000
Expected	$0.2222 \times 1000 = 222.\bar{2}$	$111.\bar{1}$	$666.\bar{6}$	

$$\chi^2 = \frac{(210-222.2)^2}{222.2} + \frac{(110-111.1)^2}{111.1} + \frac{(680-666.6)^2}{666.6} = 0.95$$

$df = 2$

$\chi^2_{0.05,2} = 5.99$

$P > \cancel{0.8} \; 0.05$, Do not reject H_0; these data provide no support for the idea the dice aren't fair.

6. (*5 points each*) For each of the following scenarios, **identify the best statistical test to use**. (Please note, do not give the answer to the specific question, but simply state the best test to use for the scenario.)

a. Asking whether, when given a choice, starfish eat a large mussel or a small mussel first.

Binomial test

or (χ^2 Goodness-of-fit if the sample sizes are large enough)

b. Asking whether human weight changes after two months on a vegetarian diet.

Paired t-test

c. Asking whether the distribution of horn length in white-tailed deer has a normal distribution.

Shapiro-Wilk test [from Chapter 13 – everyone was given full marks]

d. Asking whether the variance of the horn length of male antelope is the same as the variance of horn length in female antelope.

Levene's test

(F test if the distributions are both normal.)

7. Mueller and Oppenheimer (2014) performed a study comparing the usefulness of taking notes in longhand to note-taking using a laptop. Students were assigned to either use a pen or a laptop to take notes on a TED talk, and later they were tested for their conceptual understanding of the material. Each was given a score on that test. 28 students took notes in longhand, and 29 took notes on the laptop. The mean score on the exam was 0.154 for the long hand students (with standard deviation 1.08), while the mean score was –0.156 for the laptop group (with standard deviation 0.915).

a. (7 *points*) What is the 95% confidence interval for the mean score of the longhand group?

$\bar{X} = 0.154$

$s = 1.08$

$n = 28$

$t_{0.05(2),27} = 2.05$

$\bar{X} \pm t_{0.05(2),df} \frac{s}{\sqrt{n}}$

$0.154 \pm 2.05 \frac{1.08}{\sqrt{28}}$

0.154 ± 0.418

(or $-0.264 < \mu < 0.572$)

b. (15 *points*) Do a hypothesis test to compare the means of these two groups. What can you conclude about the effectiveness of these two forms of note-taking?

H_0: The mean score with laptops equals the mean score with longhand.

2 sample t-test $\quad df_1 = 27 \quad df_2 = 28$

$s_p^2 = \frac{27(1.08)^2 + 28(0.915)^2}{27 + 28}$

$= 0.99882$

$SE_{\bar{Y}_1 - \bar{Y}_2} = \sqrt{0.99882\left(\frac{1}{28} + \frac{1}{29}\right)}$

$= 0.2648$

$t = \frac{(0.154 - (-0.156))}{0.2648} = 1.17$

$df = 28 + 29 - 2 = 55$

$t_{0.05(2),55} = 2.00$

$P > 0.05$; Do not reject H_0; Insufficient data to reject idea that laptop and long hand note taking are similar for learning scores.