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Assignment 5

Due: Friday October 23, 2020 11:59 PM (Atlantic Daylight Time)

Assignment description

If you use R in a question, make sure you include the relevant R commands and output.

For a hypothesis testing question, always state clearly the null and alternative hypothesis, report the test statistic and the P-value, and draw an appropriate conclusion.

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After you have completed the assignment, please save, scan, or take photos of your work and upload your files to the questions below. Crowdmark accepts PDF, JPG, and PNG file formats.

Q1 (8 points)

In a test of Murphy's law, pieces of toast were buttered on one side and then dropped. Murphy's law predicted that they will land butter-side down. Out of 9821 slices of toast dropped, 6101 landed butter-side down.

(a) What is the best estimate for the probability of a piece of toast landing butter-side down?

Calculate the standard error of the estimate.

(b) What is a 95% confidence interval for the probability of a piece of toast landing butter-side down? Use the Agresti-Coull method.

(c) Using the result of part (b), is it plausible that there is a 50:50 chance of the toast landing butter-side down or butter-side up?

(d) Is there evidence that pieces of toast are more likely to land butter-side down? Carry out a one-sided hypothesis test. Use $\alpha = 0.01$.

Q2 (4 points)

Each member of a large genetics class grows 12 pea plants from an independent pea family. Each family is expected to have $3/4$ plants with smooth peas and $1/4$ plants with wrinkled peas.

- (a) On average, how many wrinkled pea plants will a student see in her 12 plants?
- (b) What is the standard deviation of the proportion of wrinkled pea plants per student?
- (c) What is the variance of the proportion of wrinkled pea plants per student?
- (d) Predict what proportion of the students saw exactly two wrinkled pea plants in their sample.

Q3 (6 points)

In north America, between 100 million to 1 billion birds die each year by crashing into windows on buildings, more than any other human related cause. This figure represents up to 5% of all birds in the area. One possible solution is to construct windows angled down slightly, so that they reflect the ground rather than an image of the sky to a flying bird. An experiment by Klem et al. (2004) compared the number of birds that died as a result of vertical windows, windows angled 20 degrees off vertical, and windows angled 40 degrees off vertical. The angles were randomly assigned with equal probability to six windows and window locations were identical in every respect except angle. Over the course of the experiment, 30 birds were killed by windows in the vertical orientation, 15 were killed by windows set at 20 degrees off vertical, and 8 were killed by windows set at 40 degrees off vertical.

- (a) Clearly state an appropriate null hypothesis and an alternative hypothesis.
- (b) What proportion of deaths occurred while the windows were set at a vertical orientation?
- (c) What statistical test would you use to test the hypotheses?
- (d) Carry out the statistical test from part (c). Is there evidence that windows angle affects the mortality rates of birds?

Q4 (5 points)

The white "spirit" black bear (or Kermode), *Ursus americanus kermodei*, differs from the ordinary black bear by a single amino acid change in the *melanocortin 1 receptor* gene (MC1R). In this population, the gene has two forms (or alleles); the "white" allele *b* and the "black" allele *B*. The trait is recessive: white bears have two copies of the white allele of this gene (*bb*), where a bear is black if it has one or two copies of the black allele (*Bb* or *BB*). Both color morphs and all three genotypes are found together in the bear population of the northwest coast of British Columbia. If possessing the white allele has no effect on growth, survival, reproductive success, or mating patterns of individual bears, then the frequency of individuals with 0, 1 or 2 copies of the white allele (*b*) in the population will follow a binomial distribution. To investigate, Hedrick and Ritland (2012) sampled and genotyped 87 bears from the northwest coast: 42 were *BB*, 24 were *Bb* and 21 were *bb*. Assume that this is a random sample of bears.

- (a) Estimate the fraction of *b* alleles in the population (note each bear has two copies of the gene).
- (b) With your estimate of the fraction of *b* alleles, and assuming a binomial distribution, calculate the expected frequency of bears with 0, 1 or 2 copies.

(c) A formal hypothesis test was carried out to compare the observed and expected frequencies of genotypes. What are the null and alternative hypotheses?

(d) What are the degrees of freedom for the test statistic?

(e) The test gave a P-value of 0.0001. Which of the following statements is *false*?

- i. The observed frequencies are compatible with a binomial distribution.
- ii. The difference between the observed and expected frequencies is statistically significant.
- iii. The test statistic exceeds the critical value corresponding $\alpha = 0.05$.
- iv. The difference is large between the true genotype frequencies in the bear population and that expected under the binomial distribution.